PACIFICORP ENERGY
A DIVISION OF PACIFICORP

825 NE Multnomah, Suite 1500
Portland, Oregon 97232

August 15, 2014

Felicia Marcus, Chair
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814

Subject: **Transmittal of Revised Clean Water Act Section 401 Water Quality Certification Application for the Klamath Hydroelectric Project and Update on Implementation of the Klamath Hydroelectric Settlement Agreement**

Dear Ms. Marcus,

On June 13, 2013, PacifiCorp provided the State Water Resources Control Board with an update on implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) and described PacifiCorp's plan and schedule for updating its water quality certification application for the Klamath Hydroelectric Project (Project). The primary purpose of the certification update was to incorporate the large volume of technical information and data developed since the last significant application update in 2008. Consistent with the schedule described in the June 13, 2013 correspondence, PacifiCorp's revised water quality certification application is enclosed. As we discussed with your staff, several sections of this application will be refined and further updated as additional information is developed through ongoing studies and in response to staff comments. In addition, PacifiCorp will withdraw and resubmit this certification application before December 2, 2014 to ensure that there is no waiver of the State Water Resources Control Board's water quality certification.

Also enclosed is a copy of PacifiCorp's *2014 Klamath Hydroelectric Settlement Agreement Implementation Report*. This report describes the status of the many actions PacifiCorp is currently undertaking in collaboration with settlement stakeholders to improve water quality within the Klamath Basin and enhance fish habitat conditions in the Klamath River. PacifiCorp remains committed to the successful implementation of the Klamath Hydroelectric Settlement Agreement.

Finally, as you may be aware, there has been significant progress on several important KHSA conditions. First, the California Legislature and Governor agreed this week on a bond package that, if approved, will provide important state funding to implement the KHSA. Also, all four Senators in California and Oregon support the Klamath Settlements and have co-sponsored federal legislation that will provide the necessary federal authorizations to approve and carry out the KHSA. This legislation (S. 2379) was introduced in May of this year and was the subject of a June 3, 2014 hearing before the Senate Energy and Natural Resources Committee. In light of these developments, PacifiCorp remains optimistic that many of the critical conditions in the KHSA will soon be fulfilled.

If you have any questions regarding the attached revised and updated application or the implementation report, please feel free to contact me.

Sincerely,

Tim Hemstreet

Tim Hemstreet, P.E.
Klamath Licensing Manager

cc: Frances Spivy-Weber, Vice Chair, SWRCB
Tam M. Doduc, Member, SWRCB
Steven Moore, Member, SWRCB
Dorene D'Adamo, Member, SWRCB
Caren Trgovcich, SWRCB
Michael Lauffer, SWRCB
Barbara Evoy, SWRCB
Parker Thaler, SWRCB
Matt St. John, NCRWQCB
Rob Donlan, Ellison, Schneider & Harris LLP

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
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August 2014

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EXECUTIVE SUMMARY

This document contains PacifiCorp's application to the State Water Resources Control Board for water quality certification of the Klamath Hydroelectric Project (Project) pursuant to Section 401 of the federal Clean Water Act. The Project is owned and operated by PacifiCorp and is located along the upper Klamath River in Siskiyou County in California and Klamath County in Oregon. This application for water quality certification analyzes water quality conditions within the Project area in California, 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 as designated in the Water Quality Control Plan for the North Coast Region (Basin Plan).

From a water quality perspective, the Klamath River is often described as an "upside down" system (e.g., Oliver et al. 2014). Unlike every other major river system in California, water quality in the Klamath River generally improves—significantly—as it moves about 250 miles downstream from Upper Klamath Lake to the estuary. Upper Klamath Lake, which sits above the Project area, is 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 coming in to the Project area is affected by irrigation diversions for agricultural uses, and by discharges from agriculture, municipal, and industrial operations.

Downstream of the Project, where water quality conditions in the Klamath River are substantially improved compared to its source at Upper Klamath Lake, important salmonid populations occur in the Klamath River that support commercial and recreational fisheries, and Native American uses. PacifiCorp's Iron Gate fish hatchery, which is fully funded by PacifiCorp and operated by the California Department of Fish and Wildlife, is a significant contributor of Chinook salmon, coho salmon, and steelhead to the Klamath River salmonid fisheries. During warmer parts of the year, hatchery operations depend on cool water stored in the hypolimnion of Iron Gate reservoir. In addition to the hatchery's contribution to fisheries, since 2009, PacifiCorp has been implementing a number of habitat enhancement actions and activities on the Klamath River and its tributaries to benefit coho salmon below Iron Gate dam through PacifiCorp's Coho Salmon Habitat Conservation Plan.

In general, the Project area occupies a dividing line—and provides a buffer of sorts—between these two differing aquatic environments in the Klamath River at its source at Upper Klamath Lake and downstream of Iron Gate dam. Compared to water quality conditions in Upper Klamath, the Project's effects on water quality conditions downstream are comparatively mostly beneficial or neutral, and limited in magnitude and duration to within the vicinity of the Project facilities. As described further in this application, an important beneficial effect is that the presence of the Project's Copco and Iron Gate reservoirs allows settling and retention of a significant amount of the large nutrient and organic loads from Upper Klamath Lake. This settling and retention reduces the loading of nutrients and organic matter to the lower Klamath River. But for the Project, this settling and processing of nutrients and organic matter would otherwise occur in the lower river and estuary.

A consequence of the substantial nutrient loads from Upper Klamath Lake (and other upstream sources) is periodic abundant seasonal blooms of algae in Copco and Iron Gate reservoirs. These blooms at times include the blue-green algae *Microcystis*, which is of particular interest because of its potential to produce toxins (i.e., microcystin) in the reservoirs that can present a potential public health risk at certain times and locations. Copco and Iron Gate reservoirs provide lacustrine conditions where these algae can grow. However, the abundant algae growth in the reservoirs is primarily caused by the large loads of nutrients flowing into the Project area from Upper Klamath Lake (and other upstream sources). *Microcystis* blooms in the Klamath Basin and the Project reservoirs are similar to an increasing incidence of toxin-producing blue-green algae elsewhere in California and the U.S. To address these conditions, PacifiCorp proposes to implement a Reservoir Management Plan (Appendix B). Actions implemented through the Reservoir Management Plan are aimed primarily at improving water quality conditions in the Project reservoirs related to algae production from organic and nutrient loads contributed from sources upstream of the Project.

The Project reservoirs also can affect water temperature and dissolved oxygen conditions below the Project during some periods of the year. The large organic loads from upstream of the Project can result in decreased dissolved oxygen levels within and immediately below the Project area. Although the Project does not contribute to these large upstream organic loads, the settling and processing of these organic loads in the Project reservoirs can at times affect dissolved oxygen in the river below Iron Gate reservoir. As described in this application, PacifiCorp has implemented turbine venting at the Iron Gate powerhouse that has increased dissolved oxygen levels below Iron Gate dam. In addition, PacifiCorp's Reservoir Management Plan (Appendix B) proposes to further assess the potential use of oxygenation systems at Copco and Iron Gate reservoirs to enhance dissolved oxygen in the reservoirs.

During the fall months, the mass of the Project reservoirs can affect water 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. This thermal lag does not affect beneficial uses of the Klamath River downstream of the Project, because water temperatures tend to be decreasing during this period to levels that are suitable for anadromous fish and other beneficial uses downstream of Iron Gate dam. PacifiCorp proposes to work with the State Water Resources Control Board and fisheries agencies to explore opportunities for using the limited cool water storage in Iron Gate reservoir, and other possible management techniques and technologies, to protect and enhance beneficial uses downstream of Iron Gate dam. The use of cool water storage in Iron Gate reservoir must be balanced against, and reconciled with, existing use of this cool water 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 through other processes, such as the 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.[1]

[1] 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 the Oregon 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 water quality certification (WQC) 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. PacifiCorp first submitted a WQC application for the relicensing of the Project to the State Water Board in March 2006 and has annually withdrawn and resubmitted the application since then in order to allow the State Water Board additional time to act on the application. This submission of the application includes new supporting 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 169 megawatts (MW).

The Federal Energy Regulatory Commission (FERC) licenses the Project under the Federal Power Act (Project No. 2082). In February 2004, PacifiCorp submitted the final application to FERC for a new Project license (PacifiCorp 2004a, 2004b, 2004c, 2004d). The application is pending. The current FERC license for the Project expired on March 1, 2006. Under federal law, PacifiCorp continues to operate the Project under annual licenses from FERC pending final resolution of the FERC licensing process.

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 WQC application to the State Water Board for the California portions of the Project. PacifiCorp is simultaneously submitting a Section 401 WQC 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) 813-6170

Applicant Agent

Mr. Tim Hemstreet
Project Manager, Hydro Licensing
PacifiCorp
825 N.E. Multnomah Street, Suite 1500
Portland, OR 97232
(503) 813-6170

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, which is located in Oregon, 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 Klamath River and 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 Creek and Fall Creek 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.

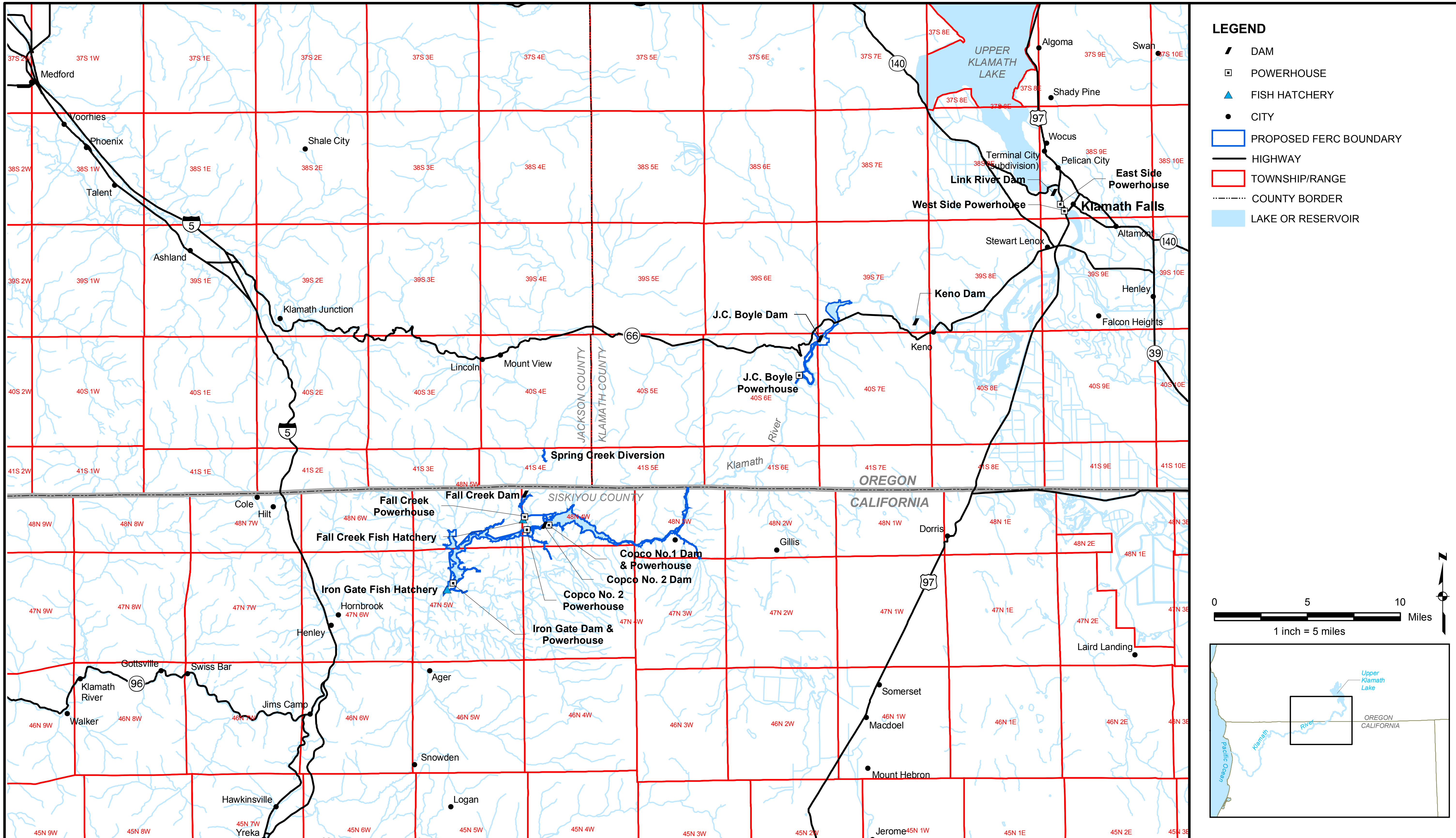
- The East Side (3.2 MW) and West Side (0.6 MW) powerhouses are associated with the U.S. Bureau of Reclamation’s (Reclamation) Link River dam. The developments are located near RM 254 within the city limits of Klamath Falls, Oregon. PacifiCorp proposes to decommission the East Side and West Side developments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

Figure

2.2-1 Klamath Hydroelectric Project Location

Front

(11x17 color)



Klamath Hydroelectric Project

Figure 2.2-1
Klamath Hydroelectric Project Location

2.3 WATERS 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 the Klamath River and 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 WQC application by reference. Final action by FERC on the license application is pending. Under federal law, PacifiCorp continues to operate the Project under annual licenses from FERC pending final resolution of the FERC licensing process.

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)
- "Notice of Public Meetings Concerning the Relicensing of the Klamath Hydroelectric Project under P-2082" (December 24, 2008)
- "Notice of Public Meeting Agenda Klamath Hydroelectric Project Regarding PacifiCorp under P-2082" (January 1, 2009)

- “Notice of Designation of Certain Commission Staff as Non-decisional Regarding PacifiCorp’s Klamath Hydro Project” (February 4, 2009)

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 submis-sion December 12,	Includes electronic input and output files of all water quality modeling runs that have been presented to the Commission and stakeholders

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

	2005	
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
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**
PacifiCorp Comments on the September 2006 FERC Draft Environmental Impact Statement (DEIS) for the Proposed Relicensing of the Project	December 1, 2006	Comments from PacifiCorp on the FERC DEIS on the proposed relicensing of the Project. Submitted to FERC and available from FERC's E-Library.
Causes and Effects of Nutrient Conditions in the Upper Klamath River (PacifiCorp 2006)	Submitted on December 1, 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.
PacifiCorp Responses to Comments from Various Stakeholders on the September 2006 FERC DEIS	January 24, 2007	Responses to comments from stakeholders on the September 2006 FERC DEIS for hydropower license for the Project. Submitted to FERC and available from FERC's E-Library.
PacifiCorp Comments on the National Marine Fisheries Service's (NMFS) Draft Biological Opinion on the	November 19, 2007	Comments on the NMFS Draft Biological Opinion on the proposed relicensing of the Project. Submitted to FERC and available from FERC's E-Library.

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

Proposed Relicensing of the 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.

2.5 OTHER SUPPORTING INFORMATION

2.5.1 Total Maximum Daily Loads (TMDLs)

Pursuant to Section 6.3 of the Klamath Hydroelectric Settlement Agreement (KHSA), PacifiCorp filed a "Plan for Implementing Management Strategies and Water Quality-Related Measures" with ODEQ and the North Coast Regional Water Quality Control Board (Regional Board) on February 22, 2011. This plan includes management measures that address the Regional Board's approval of the Klamath River TMDL on September 7, 2010 and ODEQ's issuance of the Upper Klamath and Lost River Subbasins TMDL on December 21, 2010. The plan includes the interim water quality measures that PacifiCorp has agreed to implement pursuant to the KHSA. The interim measures relevant to this certification application are described in the following section 2.4.8.

2.5.2 Interim Measures

PacifiCorp has been funding and implementing various Interim Measures (as set forth in Appendices C and D of the KHSA) to address water quality conditions and improve fisheries in the Klamath Basin. Under the Interim Measures (IMs), PacifiCorp is funding several water quality-related initiatives and studies, including basinwide water quality monitoring and studies intended to reduce nutrient levels in the Klamath River and improve water quality in the Project reservoirs. Other IMs include ongoing actions to improve fish habitat and flow within the Project and in the Klamath basin below Iron Gate dam. Several of the IMs are being carried out in collaboration with an Interim Measures Implementation Committee (IMIC), which is comprised of representatives from the KHSA parties and includes representatives from the State Water Resources Control Board and the Regional Board. The purpose of, and activities conducted under the relevant IMs, are summarized in following sections of this document.

2.5.2.1 Interim Measures to Address Water Quality

IM 3: Iron Gate Turbine Venting

PacifiCorp began implementing turbine venting at the Iron Gate powerhouse beginning in 2009 to improve dissolved oxygen (DO) concentrations downstream of Iron Gate dam. Passive venting of the Iron Gate turbine was successfully tested at the Iron Gate powerhouse in the fall of 2008 and PacifiCorp installed a blower system at the Iron Gate powerhouse in January 2010 to enhance the effectiveness of turbine venting. The combined system was tested in 2010 and demonstrated an ability to increase DO levels. PacifiCorp has been implementing turbine venting on an ongoing basis since 2010 and developed a turbine venting Standard Operating Procedure (SOP) in early 2013 consistent with the terms of PacifiCorp's incidental take permit for coho salmon (as discussed further under Section 2.5.3.2 below).

IM 10: Water Quality Conference

PacifiCorp provided funding of $150,000 to convene a basin-wide technical conference on water quality which was conducted from September 11-13, 2012 in Sacramento, California and to develop a technical report on nutrient reduction techniques applicable to the Upper Klamath Basin. The goal of the workshop was to inform participants on water quality conditions in the Klamath River basin and engage invited experts and managers to evaluate large-scale nutrient and organic matter reduction technologies for application in the Klamath basin. PacifiCorp, the Regional Board, and ODEQ formed a steering committee to organize the workshop and hire a consultant team to facilitate the workshop and develop report materials.

Over 100 invited participants attended the workshop, where participants ranked multiple water quality improvement techniques and engaged in a design charrette. Following the workshop, feedback from participants was used by the consultant team to develop pilot project conceptual designs for three overarching project types: wetland rehabilitation; sediment removal (dredging); and sediment sequestration of phosphorus with oxygenation/aeration. No single approach to addressing water quality improvements was selected because the current scale of the problem is too large. Instead, the consultant team developed conceptual designs for multiple pilot projects at several locations in the Upper Klamath Basin to treat both the symptoms and the causes of water quality problems. A report on the outcome from the workshop activities and post-workshop analysis was released in September 2013 (Stillwater et al. 2013), and is available at http://www.stillwatersci.com/case_studies.php?cid=68.

IM 11: Interim Water Quality Improvements

IM 11 is intended to address water quality improvement in the Klamath River. Regarding IM 11, the KHSA states "The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir." IM 11 calls for PacifiCorp to fund studies or pilot projects in consultation with the IMIC to address four categories of studies: (1) a water quality accounting framework; (2) evaluation of treatment by wetlands; (3) reservoir water quality control techniques; and (4) improvement of DO in J.C. Boyle reservoir. Since 2010, PacifiCorp has been consulting with the IMIC on study design and analysis. Reports on these water quality studies and pilot projects can be found on PacifiCorp's website (http://www.pacificorp.com/es/hydro/hl/kr.html). The relevant activities conducted to-date under IM 11 are summarized below.

Water Quality Accounting Framework

PacifiCorp is working in cooperation with the Regional Board, ODEQ, and United States Environmental Protection Agency (USEPA) Regions 9 and 10 and other interested parties to develop a Klamath basin water quality improvement tracking and accounting program through which water quality improvements can be tracked and investments in water quality improvements can be identified to maximize the benefits of water quality improvement investments. A Protocol Handbook was completed in 2012 and PacifiCorp remains engaged in this process. PacifiCorp is committed to seeking opportunities to use the Protocol Handbook to demonstrate water quality improvements and quantify the water quality benefits of actions that are being implemented to conserve and restore Klamath basin aquatic habitats.

Evaluation of Treatment by Wetlands

In 2012, PacifiCorp conducted a study that included: 1) use of wetland design tools to provide estimates of wetland size requirements to achieve nutrient load reductions at various assumed levels; 2) an assessment of pretreatment methods options to enhance the effectiveness of a constructed treatment wetland; and 3) identification of logical next steps to more specifically ascertain the types, sizes, configurations, and locations of potential treatment wetlands. A final report was produced in August 2012 that presents detailed information on the applicability of wetlands to address Klamath River nutrient impairment and presents several potential supplemental technologies to enhance treatment by wetlands. The final report has informed discussions of constructed wetlands treatment as a tool to reduce Klamath River nutrient concentrations, including at the Interim Measure 10 Water Quality Conference (as discussed in the previous section).

In 2013-2014, PacifiCorp is conducting planning and design for a proposed demonstration wetlands facility (DWF) in the Upper Klamath basin. The DWF would provide an important opportunity for interested stakeholders and researchers to investigate the site-specific requirements, effectiveness, feasibility, and costs of wetland technologies in the Upper Klamath basin. PacifiCorp is coordinating this work with a stakeholder-based Technical Advisory Committee (TAC) to develop a DWF Research and Implementation Plan that will lay out the planning, design, and implementation of the DWF, including locating potential sites for the DWF. The DWF itself would be constructed, operated, and maintained by stakeholder "partners" that have an interest in pursuing the unique and important wetland research and demonstration opportunities that the DWF would provide to inform basin-wide planning for water quality improvement strategies.

Evaluation of Organic Matter Removal for Keno Reservoir

This study includes an assessment of the potential use of hydrodynamic separation and/or screening to remove phytoplankton and larger particulate matter from the water as a means to reduce nutrient and organic matter loading in the Klamath River. Field tests of hydrodynamic separation were conducted in 2011 and 2012. A draft technical report on these results was distributed to the IMIC in April 2013. Continued work on this technology is proposed for 2013-2014 to assess performance objectives that would be necessary to achieve meaningful water quality improvements, which will then inform the development of estimated costs for such a system.

Evaluation of J.C. Boyle Reservoir Dissolved Oxygen Improvement

In 2011-2013, PacifiCorp conducted planning for, and testing of, technologies for improving DO conditions in J.C. Boyle reservoir. Information was gathered on commercially available technologies for improving DO in the reservoir, including oxygenation, air injection, and mechanical mixing. During 2011, study activities included field assessment of a specific oxygenation method with potential application to J.C. Boyle reservoir – the Supersaturated Dissolved Oxygen (SDOX®) system. The SDOX® technology involves withdrawing a small stream of water from the body of water to be treated, bringing that stream up to a pressurized saturation tank where oxygen gas is pre-dissolved into the stream to achieve a supersaturated DO concentration. The stream of water is then re-injected back into the main water body, thereby increasing the DO concentration in the receiving water. A pilot demonstration, conducted in September 2011, showed a rise in DO levels within the reservoir. A report was submitted to the IMIC in March 2013 on the assessment of DO improvement technologies that may be applicable to J.C. Boyle reservoir.

Testing of Intake Cover for Water Quality Control in Iron Gate Reservoir

Since 2011, PacifiCorp has been conducting studies to assess a cover, or barrier, at the Iron Gate dam intake to improve the quality of water discharged from the powerhouse. The concept behind an intake barrier is to control the depth at which water is withdrawn from the reservoir into the intake, and thereby potentially enhance water quality downstream of Iron Gate dam by excluding or reducing the potential entrainment of biomass from blooms of cyanobacteria (blue-green algae) and potential associated algal toxins (i.e., microcystin).

In 2011 and 2012, PacifiCorp successfully tested the deployment of a barrier in front of the Iron Gate dam intake. The purpose of the 2011 test was to design and construct a 12-foot intake barrier and evaluate if the barrier could be safely and successfully deployed and retrieved from the intake without disrupting project operations. Subsequent work in August 2012 evaluated water quality effects below Iron Gate dam during cover deployment as well as changes in the withdrawal zone within the reservoir. Based on the initial results from the field work, it appears that the effectiveness of the cover employed for the study may be limited temporally as hydraulics around the intake re-adjust following cover deployment, although short-term improvements in water quality may occur. A report was submitted to the IMIC in April 2013 on results to date.

In 2013-2014, PacifiCorp plans to continue conducting further design and testing of intake barrier deployments to improve water quality downstream of Iron Gate dam. Based on the results of the previous studies and ongoing data collection, PacifiCorp plans to develop a refined design for a potential cover and/or barrier curtain system for implementation at Iron Gate.

Pilot Studies of Algal Conditions Management in Project Reservoirs

Since 2008, PacifiCorp has been evaluating various algaecides as a potential tool to locally improve water quality conditions in Project reservoirs. This study is intended to assess whether algaecide may be one of many potential tools for managing reservoir water quality conditions in local portions of Project reservoirs (such as public access areas).

From 2008 to 2011, studies were conducted using water from Copco reservoir in isolated containers to evaluate the effects of applying algaecide in order to determine whether such treatment may be effective at reducing algae concentrations without increasing microcystin concentrations as result of algal cell lysing. The results from these tests indicated that algaecide can be successful in reducing algal concentration while also reducing microcystin concentrations. However, these results were based upon treatments of limited volumes of water in a well-controlled testing environment, and follow-up on-site testing was recommended to assess direct application to Project reservoirs.

In 2012, PacifiCorp conducted a localized test application of an environmentally safe, hydrogen peroxide-based algaecide in Copco Cove (in Copco reservoir). The hydrogen peroxide-based algaecide is commonly employed throughout the country to reduce blue-green algae concentrations in drinking water reservoirs, lakes and waterbodies used for public recreation. The 2012 study built upon previous studies in which the application of a hydrogen peroxide-based algaecide demonstrated effectiveness at reducing both algal cell densities and microcystin concentrations. A report was submitted to the IMIC in April 2013 on results of the Copco Cove test application.

In 2013, PacifiCorp conducted another localized test application of the environmentally safe, hydrogen peroxide-based algaecide in Long Gulch Cove (in Iron Gate reservoir) in combination with a divider curtain. The divider curtain was deployed to isolate the portion of the cove to be treated so that the persistence of the effects of the treatment could be evaluated. PacifiCorp plans to complete a report on the study results in 2014.

In 2014, PacifiCorp plans further testing of the environmentally safe, hydrogen peroxide-based algaecide in the isolated portion of Long Gulch Cove, perhaps in combination with other physical methods to disrupt production of blue-green algae, such as mechanical mixing. Based on the results of this work, a detailed technical report will be prepared, including recommendations regarding the development and implementation of strategies for algae management within reservoir coves and/or high public use areas of the reservoirs.

IM 15: Water Quality Monitoring

Since 2009, PacifiCorp has funded a baseline monitoring program that covers approximately 250 miles of river and reservoirs waters from Link dam near Klamath Falls to the Klamath River estuary throughout most of the year. Annual planning, coordination, and monitoring under this program occurs collaboratively with PacifiCorp, ODEQ, the Regional Board, USEPA Region 9, the Karuk and Yurok Tribes, and Reclamation. Parameters monitored include basic water quality (temperature, dissolved oxygen, pH, and conductivity) and a suite of nutrients.

The public health monitoring component is intended to provide timely information that can be used to inform public health agencies if cyanobacteria are present, generating toxins of concern; and to determine the need to post warning notices and issue advisories for the reservoirs and/or areas of the river. The public health monitoring is done on a more frequent basis (e.g., weekly) at public access points along Copco and Iron Gate reservoirs and the Klamath River. Water samples are rushed for analysis and results are immediately forwarded to public health entities. Bi-weekly public health memos that summarize all the public health data are provided by each monitoring entity to California's Klamath Basin Monitoring Program (KBMP) website (http://www.kbmp.net/bluegreen-algae-tracker).

The 2011 and 2012 monitoring program included a special study by the Karuk and Yurok tribes to identify appropriate systematic sampling methods for characterizing the periphyton algal community in the Klamath River. The lack of periphyton community information has been identified as a data gap in the understanding of Klamath River water quality.

2.5.2.2 Habitat Conservation Plans

PacifiCorp has worked closely with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to develop Habitat Conservation Plan (HCP) applications for Endangered Species Act (ESA) Section 10 incidental take permits (ITPs) for listed species consistent with agency regulations. PacifiCorp has prepared two HCPs – one for the threatened coho salmon and one for the endangered Lost River sucker and shortnose sucker. PacifiCorp is currently in the process of implementing the conservation measures and activities as set forth in the coho HCP and USFWS is evaluating PacifiCorp's Sucker HCP and related application.

Coho Salmon Habitat Conservation Plan

In February 2011, PacifiCorp filed the coho salmon HCP as part of an application for an ITP from NMFS. The coho salmon HCP identifies a process to implement measures that will avoid, minimize, and mitigate the effects of Project operations on coho salmon and attain the biological goals and objectives described in the HCP's coho conservation strategy. Such measures include: (1) implementing habitat enhancement activities through a Coho Enhancement Fund; (2) implementing flow releases according to Reclamation's Biological Opinion for Coho Salmon, and turbine venting at Iron Gate dam to improve habitat conditions for coho salmon in the Klamath River; (3) funding research actions on Klamath River fish disease; (4) retrieval and passage of large wood debris trapped at PacifiCorp's facilities; and (5) monitoring to assess the benefits of these measures. On February 24, 2012, NMFS issued a final ITP that authorizes potential incidental take of coho salmon that could occur as a result of PacifiCorp's operation of the Project consistent with the terms of the HCP during the 10-year permit term.

A key component of the HCP includes the selection and implementation of habitat enhancement projects to benefit coho salmon below Iron Gate dam funded through PacifiCorp's Coho Enhancement Fund. Since 2009, PacifiCorp has provided funding of $2,550,000 into the Coho Enhancement Fund. Each year, PacifiCorp, NMFS, and CDFW coordinate to select projects to be funded and implemented to benefit coho salmon. PacifiCorp has developed a partnership with the National Fish and Wildlife Foundation (NFWF) to administer the fund. This partnership allows Coho Enhancement Fund grant recipients to be eligible for additional funding through other grant programs, further enhancing the conservation benefit of the fund.

A Technical Review Team, comprised of state, federal, and tribal biologists was formed in 2012 and meets annually to review existing projects funded under the Coho Enhancement Fund and to recommend possible adaptive management changes, if warranted, based, in part, on the results of monitoring data developed from funded projects.

Other activities conducted under the HCP to date include operational adjustments to improve dissolved oxygen in flow releases from Iron Gate powerhouse through turbine venting, fish disease research, development of a hatchery and genetics management plan for Iron Gate Hatchery, delivery of flows from Iron Gate dam in support of Reclamation's regulatory requirements, and monitoring and adaptive management. PacifiCorp also developed an Iron Gate Gravel Augmentation Plan as required by the HCP, which was submitted to NMFS for review and approval. Future gravel augmentation projects conducted under the coho salmon HCP will be implemented consistent with the Gravel Augmentation Plan.

The HCP also requires water quality data collection and analysis. PacifiCorp submitted a final Water Quality Monitoring Plan to NMFS on February 24, 2013, including procedures to monitor water temperature and dissolved oxygen at designated monitoring sites. In May 2013, PacifiCorp completed arrangements with the U.S. Geological Survey (USGS) to install and collect continuous water temperature data in the Klamath River at the Orleans gaging location (USGS 11523000). Continuous monitoring of water temperature and dissolved oxygen occurred in 2013 in the Klamath River below Iron Gate Dam. Data collected will be used to develop an Annual Water Quality Monitoring Report to be submitted to NMFS to evaluate consistency with the water quality objectives contained in the coho salmon HCP.

Sucker Habitat Conservation Plan

In August 2011, PacifiCorp filed the Lost River sucker and shortnose sucker HCP as part of an application for an ITP from USFWS for operation of the Project. The HCP addresses potential incidental take of the two sucker species that could occur during the anticipated 10-year permit term. PacifiCorp submitted a revised Habitat Conservation Plan to USFWS in late 2012 and public comments on PacifiCorp's application were solicited in March 2013.

PacifiCorp anticipates that the USFWS will complete its evaluation of PacifiCorp's application for an ITP in early 2014. If approved by USFWS, an ITP would authorize potential incidental take of the two listed sucker species consistent with the terms of the HCP. The Sucker HCP identifies a conservation strategy to avoid, minimize, and mitigate take of listed suckers that includes substantial shutdown of the East Side and West Side hydroelectric developments in Oregon, continued support for an important restoration project on the Williamson River Delta, and a protocol for implementing a Sucker Conservation Fund to implement projects to improve and conserve aquatic habitat to benefit listed suckers.

2.5.2.3 Additional Interim Measures

IM 4: Hatchery and Genetics Management Plans (HGMPs)

In September 2010, a Hatchery and Genetic Management Plan (HGMP) for the Iron Gate Hatchery Coho Salmon Program was submitted to NMFS by CDFW following collaborative work among NMFS, CDFW and PacifiCorp to develop the application. The HGMP program's conservation measures, including genetic analysis, broodstock management, and rearing and release techniques, will maximize fitness and reduce straying of hatchery fish to natural spawning areas. In 2010, in cooperation with CDFW and NMFS, PacifiCorp began funding an active genetic broodstock management program at Iron Gate Hatchery. The program is based on real-time genetic analysis of coho spawning broodstock and reduces the rate of inbreeding in the hatchery. Additionally, changes have been made to increase the proportion of jacks and natural-origin fish in the total hatchery coho spawning population. These measures are anticipated to increase population diversity and fitness and reduce genetic divergence of the hatchery and naturally-spawning coho populations. Hatchery culture practices under the HGMP program are also being improved to increase egg-to-smolt survival rates through the introduction of state-of-the-art moist-air incubators to increase survival during egg incubation and by covering raceways with netting to reduce bird predation.

NMFS published the HGMP and associated documents in February 2013 to solicit public review and comment to inform its evaluation of the HGMP and a decision about whether to approve the HGMP. The California Hatchery Scientific Review Group recommended that the Iron Gate HGMP be approved in its April 2012 report. In 2014, PacifiCorp plans to continue the HGMP development process by collaborating with NMFS and CDFW to develop HGMPs for the Iron Gate Hatchery Chinook salmon and steelhead programs.

IM 5: Iron Gate Flow Variability

PacifiCorp has been implementing variable flow releases at Iron Gate dam consistent with flow directives issued by Reclamation, The recently-issued joint Biological Opinion on Reclamation's proposed Klamath Project operations for the period 2013-2023 includes provisions for more variable flow releases from Iron Gate dam to provide benefits to listed species (NMFS and USFWS 2013). PacifiCorp is working closely with Reclamation to coordinate river operations and dam releases in a manner that achieves Reclamation's flow requirements below Iron Gate dam while also meeting operational and other regulatory objectives of Reclamation and PacifiCorp.

IM 6: Fish Disease Relationship Studies

Per IM 6 of the KHSA, PacifiCorp has provided funding in the amount of $500,000 to study fish disease relationships downstream of Iron Gate dam. Humboldt State University, Oregon State University, and the Karuk and Yurok Tribes collaborated on a research proposal to examine how management actions could be focused to reduce the incidence of *Ceratomyxa shasta*, a myxozoan parasite of salmonids which causes extensive losses of outmigrant salmon smolts in the Klamath River.

IM 17: Fall Creek Flow Releases

Per IM 17 of the KHSA, PacifiCorp adjusted instream flow releases in the Fall Creek bypass reach from 0.5 cfs to 5 cfs on May 18, 2010. The additional instream flow release is being provided through an existing bypass culvert at the Fall Creek diversion dam. PacifiCorp's operations staff monitors this flow release during the course of their routine visits to the Fall Creek diversion dam to ensure that the instream flow is maintained.

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. 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 <u>Copco No. 1 Development</u>

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 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 typically operate in a coordinated fashion. 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 often mimics flow through J.C. Boyle on a daily average basis (with a time lag). Copco No. 2 has virtually no storage reservoir and typically operates in conjunction with Copco No. 1. That is, Copco No. 2 generation and hydraulic discharge typically follows 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 during maintenance activities that require shutdown of the turbine or dewatering of the penstock, during high flow events, or when downstream flow requirements at Iron Gate Dam necessitate flow releases from Copco Reservoir in excess of powerhouse capacity.

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 typically operates in conjunction with Copco No. 1 to maximize generation efficiency.

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 typically 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 typically 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 zoned earth and 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 passage of high flows downstream of 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 sheet pile wall 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 that may be inundated under 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 to re-regulate fluctuating river flows from the Copco No. 1 and Copco No. 2 peaking operations. Releases through the turbine can be as much as 1,735 cfs. When flows are higher, or when higher flows are needed to meet downstream flow requirements, additional water is passed over the ungated spillway. The amount of spill is controlled to the extent possible through the operations of the upstream facilities. If a consistent spill is needed at Iron Gate dam, Copco No. 1 and Copco No. 2 cannot operate in a peaking operation, but must provide a constant flow to maintain Iron Gate reservoir elevations and thereby provide steady flows downstream.

The Iron Gate Development is operated to serve as the Project's regulating facility and generation schedules reflect instream flow requirements and ramp rates as directed by Reclamation. (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. Monitoring and control is provided 24 hours per day, 7 days per week. Local operators can start and stop the unit and make adjustments to unit loading, but unit control generally is performed automatically on a defined (preprogrammed) ramp rate. The unit can be tripped remotely.

3.1.3.3 Existing Instream Flow Releases and Ramping Rates

Instream flow, flow variability, and flow ramping rate measures at Iron Gate dam are established to benefit listed coho salmon downstream of Iron Gate dam. Specific procedures for the implementation of these three flow-related measures are described further in section VI (pages 89-92) of the Coho salmon HCP (PacifiCorp 2012). These measures also are consistent with Reclamation's Biological Assessment (BA) on the Klamath Irrigation Project (Reclamation 2012) and the 2013 Biological Opinions issued to Reclamation in response to the BA (NMFS and USFWS 2013). As contemplated in the Coho salmon

HCP (PacifiCorp 2012), the Reclamation BA (Reclamation 2012), and the 2013 Biological Opinions (NMFS and USFWS 2013), PacifiCorp coordinates with Reclamation over flow-related actions.

Instream Flow Releases

PacifiCorp coordinates with Reclamation and NMFS to provide instream flow releases from Iron Gate dam that are consistent with applicable requirements stipulated in the Coho salmon HCP (PacifiCorp 2012), the Reclamation BA (Reclamation 2012), and the 2013 Biological Opinion (NMFS and USFWS 2013). Per the recent Biological Opinion, Iron Gate flow release targets are adjusted on a daily basis in order to better mimic the natural flow variability in the Klamath River. Flow released from Iron Gate dam are based on actual recent hydrological conditions in the Klamath Basin, with flows mimicking the pattern of inflows into Upper Klamath Lake as determined from observations of Williamson River inflows observed the prior week. The volume of flow releases from Iron Gate Dam is determined by Reclamation and takes into account Upper Klamath Lake storage, accretions between Link River Dam and Iron Gate Dam, and other factors as detailed in Reclamation's Biological Opinion. The Biological Opinion also established minimum flows that are shown in Table 3.1-3 below.

.On rare occasions, emergencies may arise that cause PacifiCorp to deviate from the Iron Gate dam release target. Emergencies may include, but are not limited to, flood prevention or facility and regional electrical service emergencies, public and operational safety. PacifiCorp would coordinate closely with Reclamation should the need to deviate from the Iron Gate dam flow target be identified. Such emergencies occur infrequently, and are not expected to significantly influence flows downstream of Iron Gate dam.

Iron Gate Ramping Rates

PacifiCorp maintains ramp rates of flow releases from Iron Gate dam as specified in the HCP and the 2013 Biological Opinion (NMFS and USFWS 2013). As specified, flow releases are ramped down (decreased) by no more than 150 cfs in 24 hours and no more than 50 cfs in any 2-hour period when flows are less than or equal to 1,750 cfs. Flow releases are ramped down by no more than 300 cfs in 24 hours and no more than 125 cfs in any 4-hour period when flows are greater than 1,750 cfs, but less than 3,000 cfs. The 2013 Biological Opinion (NMFS and USFWS 2013) does not contain specific daily or hourly ramp rates when the flow releases at Iron Gate dam are greater than 3,000 cfs. The NMFS 2013 Biological Opinion assumes Reclamation's proposed approach that the ramp-down of flows greater than 3,000 cfs should mimic natural hydrologic conditions of the basin upstream of Iron Gate dam.

Table 3.1-3. Average Daily Target Minimum Flow Below Iron Gate Dam per Reclamation's 2013 Biological Opinion (NMFS and USFWS 2013)

Month	Average Daily Minimum Target Flows (cfs)
January	950
February	950
March	1,000
April	1,325
May	1.175
June	1,025
July	900
August	900

Table 3.1-3. Average Daily Target Minimum Flow Below Iron Gate Dam per Reclamation's 2013 Biological Opinion (NMFS and USFWS 2013)

Month	Average Daily Minimum Target Flows (cfs)
September	1,000
October	1,000
November	1,000
December	950

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 Klamath River and 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. Historically, per PacifiCorp's existing FERC license, the facility was operated at a constant discharge equal to the diversion dam inflow minus the 0.5 cfs instream release. However, per IM 17 of the KHSA, PacifiCorp adjusted instream flow releases in the Fall Creek bypass reach from 0.5 cfs to 5 cfs on May 18, 2010. The additional instream flow release is being provided through an existing bypass culvert at the Fall Creek diversion dam. PacifiCorp's operations staff monitors this flow release during the course of their routine visits to the Fall Creek diversion dam to ensure that the instream flow is maintained

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 and an existing bypass culvert at the Fall Creek diversion dam ensures that 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 3.1-4). A gauge (USGS No. 11512000) was historically operated downstream of the powerhouse but is no longer in operation. Flow released at the powerhouse is estimated through a flow-generation relationship.

Table 3.1-4. 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) 5 cfs pursuant to KHSA Interim Measure 17)	None

3.2 PROPOSED PROJECT

This section describes the proposed Project facilities in California. 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 Generation Equipment Upgrades

PacifiCorp periodically implements capital investments for the purpose of enhancing the generation capabilities of existing turbine-generator units at the Project. In such cases, the impetus for the overhaul and upgrade of a turbine or generator has been a need to replace major components that have reached the end of their useful life. While turbine technology has not changed significantly in many years, the advent of more powerful computers and numerical flow analysis has allowed for optimization of turbine runner designs, resulting in efficiency and capacity gains associated with a turbine overhaul incorporating a runner replacement. In this manner and considering the length of a new license, PacifiCorp expects to take advantage of the new design and analysis technology to obtain incremental gains to the efficiency and capacity for Project units. Implementation of such upgrades will be determined by the condition of generating equipment and future streamflow conditions through the Project. Generation equipment upgrades would not alter or require changes in flows through the powerhouses.

3.2.2 Instream Flows and Ramping Rates

This section provides descriptions of the proposed instream flows and ramping rate measures pertaining to the Project facilities in California under the new license. (PacifiCorp is not proposing any modifications to its operation that would affect the Project's ability to meet Reclamation's flow requirements downstream of Iron Gate dam.)

3.2.2.1 Copco No. 1 Development

There are no instream flow and ramping rate requirements at the Copco No. 1 Development. As described in section 3.1.1.1, the Copco No. 1 Development has no bypass reach since the powerhouse is located immediately below the dam. In addition, the Copco No. 1 powerhouse discharges directly into the small, 0.3-mile-long Copco No. 2 reservoir. Therefore, specific instream flow and ramping rate releases are not needed at this development.

3.2.2.2 Copco No. 2 Bypass Reach

The 1.5-mile long Copco No. 2 bypass reach extends from Copco No. 2 dam at RM 198.3 to the Copco No. 2 powerhouse at RM 196.8. Under the new license, PacifiCorp proposes to release a minimum instream flow of 10 cfs from Copco No. 2 dam to this short and narrowly confined bypass reach channel. PacifiCorp proposes to construct a new flow release facility at Copco No. 2 dam to monitor flows and provide automatic adjustments to maintain required flow releases.

PacifiCorp proposes that Project-controlled flow increases will not exceed a down-ramp rate of 125 cfs per hour with the exception of conditions beyond the Project's reasonable control. To the 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.

3.2.2.3 Copco No. 2 Powerhouse Tailrace to Iron Gate Reservoir

The Copco No. 2 powerhouse tailrace discharges back to the Klamath River at the head end of Iron Gate reservoir. As such, there are no minimum instream flow releases or ramp rate restrictions needed at this point because Copco No. 2 powerhouse discharges directly into the headwaters of Iron Gate reservoir and there are no effects to habitat or water quality conditions as a result of instream flow releases or ramp rates.

3.2.2.4 Klamath River Below Iron Gate Dam

Under the new FERC license, PacifiCorp will continue to coordinate with Reclamation and NMFS to provide instream flow releases from Iron Gate dam that are consistent with applicable requirements stipulated in the Reclamation BA (Reclamation 2012) and the 2013 Biological Opinion (NMFS and USFWS 2013). Details regarding Iron Gate flow release targets to the Klamath River per the 2013 Biological Opinion are provided in section 3.1.3.3.

At the request of the Reclamation and during emergencies and unanticipated events, PacifiCorp may deviate from the Iron Gate dam release target. Emergencies may include, but are not limited to, flood prevention or facility and regional electrical service emergencies, and public and operational safety. Unanticipated events may include pulse flow releases from the dam to provide benefits to environmental and fish and wildlife resources and ceremonial flow releases for downstream Tribal ceremonies. PacifiCorp would coordinate closely with Reclamation should the need to deviate from the Iron Gate dam flow target be identified. Such emergencies and special situations occur infrequently, and are not expected to significantly influence flows downstream of Iron Gate dam.

PacifiCorp will maintain ramp rates of flow releases from Iron Gate dam as specified in the 2013 Biological Opinion (NMFS and USFWS 2013). As specified, flow releases will be ramped down (decreased) by no more than 150 cfs in 24-hours and no more than 50 cfs in any 2-hour period when flows are less than or equal to 1,750 cfs. Flow releases will be ramped down by no more than 300 cfs in 24 hours and no more than 125 cfs in any 4-hour period when flows are greater than 1,750 cfs, but less than 3,000 cfs. The 2013 Biological Opinion (NMFS and USFWS 2013) does not contain specific daily or hourly ramp rates when the flow releases at Iron Gate dam are greater than 3,000 cfs. Additional details regarding ramp rates of flow releases from Iron Gate dam per the 2013 Biological Opinion are provided in section 3.1.3.3.

3.2.2.5 Fall Creek Bypass

Under the new FERC license, PacifiCorp proposes a minimum of 5 cfs into the Fall Creek bypass reach plus a 15 cfs continuous flow downstream of the bypass confluence. In March 2014, PacifiCorp submitted a petition to the State Water Board under Water Code section 1707 to recognize the instream use of 5 cfs in the bypass reach. The State Water Board is currently processing the petition. For the continuous release downstream of the bypass confluence, PacifiCorp proposes to construct a new release structure to maintain a continuous release at the Fall Creek diversion dam. Due to the continuous release, flows will not start and stop during operations, hence, flow ramping rates are not needed to moderate flow changes as a result of Project operations.

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 February 2008 (PacifiCorp 2008a). 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), and Reclamation (2000). 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, ODEQ 2010, NCRWQCB 2010). 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 inflowing loads of nutrients and organic matter from upstream sources is most appropriately addressed through implementation of the Total Maximum Daily Loads (TMDLs) established by the State of California's North Coast Regional Water Quality Control Board (NCRWQCB 2010) and ODEQ (2010). 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 achieving the water quality improvements anticipated by the TMDLs, particularly as they may pertain to Copco and Iron Gate reservoirs.

Over the past several years, PacifiCorp has conducted testing of various technologies and measures for water quality management and enhancement in Copco and Iron Gate reservoirs. In 2007, PacifiCorp developed a design and implementation plan for an oxygen diffuser system in Iron Gate reservoir (MEI 2007). In 2009, PacifiCorp completed a study to determine 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 completed turbine venting tests at the Iron Gate powerhouse and then implemented on-going turbine venting in 2012 to enhance dissolved oxygen conditions in releases from Iron Gate dam to the river below (see section

4.2.10). PacifiCorp conducted pilot-scale testing of solar-powered epilimnetic circulators in the reservoirs to obtain reliability and effectiveness information (Carlson and Foster 2009).

In 2012 and 2013, PacifiCorp conducted limited test applications of sodium carbonate peroxyhydrate (GreenClean PRO™) algaecide in two reservoir coves (Deas et al. 2012, Deas et al. 2014). Sodium carbonate peroxyhydrate (GreenClean PRO™) is an environmentally-safe algaecide approved by the EPA and the California Department of Pesticide Regulation (DPR) for aquatic application to control blue-green algae. Additional algaecide test applications are occurring during summer 2014 and results are pending.

In 2009, PacifiCorp implemented a multi-year study to assess the efficacy of an intake cover intended to reduce cyanobacteria entrainment into the existing Iron Gate reservoir intake (Watercourse 2013c, Watercourse 2014b). An intake cover, or other exclusion methods (e.g., geotextile curtains), could provide a straightforward means of controlling the depth at which intake waters are withdrawn from the reservoir at or near the surface; thus, providing a method for potentially reducing the amount of algae entrained into the Iron Gate intake and discharged from the powerhouse. Additional reservoir intake control testing is occurring during summer 2014 and results are pending.

Further details on planned RMP activities and proposed actions 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. In addition, the 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 have effects on the hatchery that would need to be addressed under such scenarios.

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 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.

PacifiCorp's modeling results indicate that if releases from Iron Gate dam are managed to sustain decreased temperatures, 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 release water temperature, a maximum reduction of up to 10°C is possible, but would last only for a few days until the cold water pool is depleted. The cooling benefits to the river obtained from selective withdrawals from Iron Gate reservoir would progressively diminish with distance below Iron Gate dam as the river responds 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 indicated that "emergency circumstances" would be if and when temperature conditions for downstream juvenile anadromous fish survival approach critical levels. In addition, FERC staff suggested 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[2] in Oregon, and Copco No. 1, Copco No. 2, and Iron Gate[3] 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 Energy Policy Act (EPAct)

[2] 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.

[3] 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.

trial-type proceeding[4] in 2006. 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 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 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

[4] Section 241 of the Energy Policy Act (EPAct) amends section 4(e) and section 18 of the Federal Power Act (FPA) to provide that a license applicant and any party to a license proceeding is entitled to a determination on the record on any disputed issue of material fact with respect to mandatory conditions or prescriptions filed pursuant to section 4(e) or section 18, after a trial-type hearing of no more than 90 days.

- 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 generally agrees with FERC's FEIS analysis that recommends a trap-and-haul based adaptive management approach to reintroduction before making the substantial investment in volitional fishways at the various Project facilities that would be required by the Section 18 prescriptions. It nonetheless 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 salmon 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 monitoring of the added material over the life of the new FERC license. It is proposed that 3,500 cubic yards of spawnable gravel be placed in the reach just downstream of Iron Gate dam during every 10-year period of the new license.

The results of PacifiCorp's geomorphology study (PacifiCorp, 2004h) indicate that any Project effects 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.

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 concluded that the sediment augmentation program would provide substantial benefits to spawning fish. FERC staff recommended that augmentation include a range of sediment sizes to support channel complexity and recruitment of riparian vegetation. FERC staff further indicated 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 (2007) assumed 3,500 cubic yards of sediment (likely to be primarily gravel) would provide 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. In addition, gravel augmentation may also help to reduce fish disease through scour and decreased habitat quality for the polychaete *Manayunkia speciosa*¸ the intermediate host for the pathogens *Ceratomyxa shasta* and *Parvicapsula minibicornis* that occur throughout the Klamath River below Iron Gate dam (PacifiCorp 2012).

PacifiCorp proposes that gravel augmentation would occur using a passive-placement approach. Passive placement assumes that gravel is supplied at a specific place that is also hydraulically suited for gravel entrainment and transport, and the gravel will be naturally dispersed to enhance habitat downstream (Bunte 2004). For this gravel augmentation program, the passive-placement approach is advantageous because: (1) access and placement requirements are more straightforward and easily manageable; (2) no vegetation has to be removed; and (3) there is no need for heavy equipment in the river channel. Flow entrainment and dispersal will be further enhanced by placing the gravel using a truck equipped with a high speed conveyor belt (or "gravel shooter"), which propels or slings gravel a horizontal distance of up to about 50 feet into the channel.

The proposed placement location is near the Lakeview Road Bridge (also known as the Iron Gate Hatchery Bridge) downstream from Iron Gate dam near River Mile (RM) 189.8. This location is immediately downstream of the dam, which will allow gravel to be placed: (1) in the area with existing large substrate and greatest coarsening effects of the dam; (2) at the upstream-most location, allowing gravel to be distributed downstream during peak flows; (3) on PacifiCorp property, which will eliminate the need to obtain private landowner approval for access; and (4) near a gravel stockpile area on PacifiCorp property. Assuming a shooting distance of 50 feet, much of the river could be reached from the bridge and either side of the river just downstream of the dam spillway to just below the bridge.

Gravel will be placed as necessary based upon the frequency of gravel mobilization. The target for gravel augmentation will be to place 3,500 total cubic yards of gravel during each 10-year period. The frequency of gravel placement will be determined based on monitoring to determine whether previously placed gravel has dispersed downstream. It is estimated that flows in the range of 4,500 cfs are needed to initiate transport of gravel at the proposed placement site near Iron Gate dam, with a peak flow return interval of about 1.5 years. Evaluation of peak flows since the previous placement period and monitoring of gravel transport will determine whether gravel placement is necessary for any given year.

If annual monitoring shows that previously-placed gravel has not moved, gravel will not be placed at that location the ensuing year. Moreover, if flows are not sufficient to move gravel over a period of five consecutive years, it may be necessary to identify and use an alternate gravel placement site. The selection of an alternate gravel placement site, if needed, will be done in consultation with NMFS and CDFW.

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 provides an overview of historical and current water quality conditions in the Klamath River in the vicinity of the Project. Specific water quality parameters and the Project's effects on those parameters are evaluated in Section 5.0.

4.1 OVERVIEW OF HISTORICAL WATER QUALITY CONDITIONS IN THE BASIN

Water quality in the upper Klamath River in the vicinity of the Project is strongly influenced by the abundance of nutrients (particularly nitrogen and phosphorous), organic matter, and algae entering the river at its source from the outlet of Upper Klamath Lake. Upper Klamath Lake is a large (121 mi^2), shallow (mean depth about 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).

Paleolimnological studies indicate that Upper Klamath Lake has been naturally enriched with nutrients since long before settlement of the basin by non-Native Americans. Eilers et al. (2001) concludes that Upper Klamath Lake has been a very productive lake for at least the period of record represented by the sediment stratigraphy conducted for their study (about 1,000 years). Nutrient concentrations were found to be high throughout the sediment stratigraphy period. The diatom stratigraphy showed a diverse assemblage of taxa typically found in eutrophic and hypereutrophic lakes. Colman et al. (2004) determined (through deep sediment coring in the lake) that even earlier post-glacial changes included a transition to warmer, higher-productivity diatom assemblages and a mid-Holocene interval of lower lake level and lake anoxia several thousand years ago.

In addition to the diatoms, Eilers et al. (2001) found one genus of unicellular green algae, *Pediastrum*, well represented in ancient lake sediments. *Pediastrum* is generally present in nutrient-rich lakes and is often associated with other taxa found in nutrient-enriched lakes, such as the cyanobacteria *Anacystis* and *Anabaena* (Hutchinson 1967). The abundance of *Pediastrum* remains in the sediments of Upper Klamath Lake support the view that the lake has been highly productive for a long period. Because cyanobacteria readily decompose, they are not distinguishable in the sediment stratigraphy. However, Eilers et al. (2001) found cyanobacteria akinetes (i.e., thick-walled resting-state cells of cyanobacteria) present throughout the period of record represented in the sediment stratigraphy.

Concerns about the quality of water in the Upper Klamath Lake date back to the earliest recorded contacts with the lake. The earliest-known statement regarding Upper Klamath Lake's water quality was made on August 14, 1855 by Lieutenant Abbot, who commented upon the "dark color" and "disagreeable taste" of the waters of Klamath Lake, attributing these characteristics to decaying tule growth (Wee and Herrick 2005). In September 1879, Edward Cope, a prominent naturalist and one of the founders of American paleontology, visited the Upper Klamath Basin, and remarked that Upper Klamath Lake's waters "are full of vegetable impurities living and dead" (Wee and Herrick 2005).

In 1894, Charles Gilbert, a professor of zoology at Stanford University, observed "many dead and dying fish" in both Upper Klamath Lake and the Klamath River. In 1896, Barton Evermann and Seth Meek, investigators of fish populations for the U. S. Fish Commission, noted that Upper Klamath Lake "contains considerable water vegetation." In January 1906, Joseph Lippincott, the supervising engineer of the U. S. Reclamation Service's Klamath Project, expressed concern over ice blocks being cut from the green-colored waters of Upper Klamath Lake. Lippincott noted that the Upper Klamath Lake waters were "filled with some sort of organic matter, either animal or vegetable, so that they have a decided green appearance." At that time, the U. S. Geological Survey conducted an analysis of the water and concluded that the organic matter was of "vegetable origin" (Wee and Herrick 2005).

Aside from a long natural history of nutrient-enriched conditions in Upper Klamath Lake, the sediment stratigraphy analysis of Eilers et al. (2001) indicates that more recent lake sediments show a coherent record of even higher nutrient concentrations (especially of phosphorus), elevated erosional inputs, and higher rates of sediment accumulation since about the 1930s when most anthropogenic development activities have occurred in the basin. This was accompanied by an apparent shift in the dominant phytoplankton taxa in the lake, particularly the now-dominant cyanobacteria *Aphanizomenon flos-aquae*, which are indicative of highly productive waters.

In 1953, a study was conducted by the Oregon State Sanitary Authority et al. (1955) to explain the problems associated with the *Aphanizomenon* algae at Upper Klamath Lake. The study concluded that the shallow configuration of Upper Klamath Lake provides for rapid decomposition of dead organic material and maintains the lake in almost constant nutrient circulation. The study further concluded that 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 and the Klamath River Basin Commission was formed to address interstate water-related issues. The 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, after gathering baseline data in efforts to control basin pollution, issued a report stating that "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 Upper Klamath Lake 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 of Upper Klamath Lake. In the early 1970s, the agency announced that Upper Klamath Lake would be one of seven Oregon lakes studied as part of a national survey of eutrophic waters. 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. Upper Klamath Lake was "ranked third in algal productivity and was one of the six lakes characterized as highly productive."[5]

[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.

Congress authorized the Army Corps of Engineers (Corps) to investigate potential methods of revitalizing the Upper Klamath Lake 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 Upper Klamath Lake's excessive nutrient enrichment (Bortleson and Fretwell 1993). The report concluded that the lake is naturally enriched and the changes in algae abundance and type have occurred in part as a result of natural lake-aging processes. The report also indicated that large nutrient concentrations (ranging from 0.05 to 0.24 mg/L total phosphorus) from local ground water occur in springs feeding the lake or entering the lake as ground-water flow. The report also described several likely causes for increased nutrient enrichment of the lake since the Klamath Basin was settled, including: (1) conversion of marsh to agricultural land causing release of large quantities of nutrients to the lake; (2) greater nutrient loads in streams that flow to the lake from agricultural and other land use activities in the basin; (3) increasingly abundant growths of blue-green algae making nutrients more available and causing even more abundant algal growth; and (4) increased internal recirculation of nutrients from the lake bottom sediment to the water column.

In May of 2002, ODEQ established total maximum daily loads (TMDLs) for the Upper Klamath Lake drainage (ODEQ 2002). The Upper Klamath Lake 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 Upper Klamath Lake TMDL stated that this reduction could be achieved by restoring near-lake wetlands, "upland hydrology and land cover restoration" (not specified), and reducing phosphorous discharge levels.

In 2004, the National Research Council's (NRC) Committee on Endangered and Threatened Fishes in the Klamath River Basin issued a report regarding endangered and threatened fishes in the Klamath Basin (NRC 2004). The NRC Committee had a primary interest in the water quality of Upper Klamath Lake as a factor influencing the health and survival of endangered sucker species. In this regard, the NRC Committee assessed the various previously-reported causes of Upper Klamath Lake's hypereutrophic status, including the enrichment roles played by the nutrients nitrogen and phosphorus, pH levels, dissolved oxygen levels, and the predominance of *Aphanizomenon flos-aquae* in the lake's algal populations. The NRC Committee acknowledged that typically the most effective way to limit algal growth is to restrict phosphorus loading, as assumed in ODEQ's Upper Klamath Lake TMDL. However, even if the TMDL's targeted 40 percent reduction in external phosphorus loading could be achieved, the NRC Committee concluded that such external load reduction would "probably be ineffectual … given that internal phosphorus loading is very large for Upper Klamath Lake" and that "available evidence indicated that … internal loading appeared sufficient to maintain algal populations".

The NRC Committee postulated that the influx of organic acids (called "limnohumic" acids) into the lake's waters from adjacent wetlands played a large part in inhibiting the growth of blue-green algae species before diking and subsequent drainage of the wetlands occurred for agricultural purposes (NRC 2004). According to this hypothesis, when the levels of these acids dropped after draining of the wetlands, *Aphanizomenon* was "released from suppression by weak light availability or chemical inhibition," and thereby began its ascension to its current dominant role. This hypothesis was used by the NRC Committee to further explain both the dominance of *Aphanizomenon* in the algal population, and also the increase in the amount of algae biomass in the water.

From 2001 through 2008, PacifiCorp conducted various water quality studies in support of a Final License Application (FLA) to the Federal Energy Regulatory Commission for relicensing of the Project (PacifiCorp 2004b, 2004e) and for Section 401 WQC applications (PacifiCorp 2008a, 2008b). As an initial task for these studies, available historic water quality data and information for the Project were compiled that included measurements for 66 distinct constituents from 175 sites in the Klamath River basin sampled between October 1950 and June 2001. The overall picture of the Klamath River that emerged from the historical data was one of higher production and organic matter in the upper reaches of the river (Lake Ewauna and Keno reservoir), changing to lower production and lesser organic matter in the lower reaches of the Klamath River below Iron Gate dam. The available historical data indicated as expected that Upper Klamath Lake and Klamath Straits Drain have been prolific sources of BOD, organic nitrogen, dissolved solids, turbidity (suspended solids), and phosphorus to the Klamath River.

As a subsequent task to the review of historical data, PacifiCorp conducted comprehensive water quality monitoring to assess current water quality conditions in the Klamath River between Link River dam and the Shasta River (PacifiCorp 2004e, 2006, 2008a, 2008b). The results from this monitoring are described in more detail in Section 4.2 below. As expected, these data verified that the driving force influencing water quality in the Project area is the quality of water entering the Project from Upper Klamath Lake and Klamath Straits Drain. The data demonstrated that the entire Klamath River system upstream and within the Project area, including the Klamath Straits Drain, is high in phosphorus with values well above those considered to indicate a eutrophic system (0.08 mg/L; Wetzel, 2001, p. 283). The abundant algae delivered from Upper Klamath Lake to the water entering Link River and then Lake Ewauna and Keno reservoir carries a high load of organic nitrogen and other organic matter. The respiration demands of such abundant algal production combine with BOD to consume much of the oxygen in Lake Ewauna and Keno reservoir during the summer and early fall.

4.2 CURRENT CONDITIONS AND PROCESSES AFFECTING WATER QUALITY

Flow and water quality conditions in the Klamath River vary considerably along the approximately 250 river miles from its source at the outlet of Upper Klamath Lake to the estuary at the Pacific Ocean. A wide range of natural and anthropogenic influences affect water quality throughout the river. The river begins with water of poor quality flowing out of hypereutrophic Upper Klamath Lake at Link River dam. Not far below Link River dam, the river is impounded in Keno reservoir, which includes substantial agricultural diversions and irrigation return flows, as well as municipal and industrial discharges. Downstream of Keno dam to the California border, however, the river flows through a relatively high-gradient canyon with few tributaries. The only substantial anthropogenic influence on this portion of the river is PacifiCorp's J.C. Boyle facility, which includes a reservoir with a relatively short hydraulic residence time, a four-mile bypass reach dominated by flows from groundwater springs, and peaking operations. Just downstream of the California border, Copco and Iron Gate dams create two large reservoirs with substantial hydraulic residence times. Finally, below the dams the river flows in its last 190 miles through a largely undeveloped area that receives considerable inflow from major and minor tributaries

From a water quality perspective, the Klamath River is often described as an "upside down" system (e.g., Oliver et al. 2014). In most river systems, water quality is highest at the source and degrades as water flows downstream. By contrast, the water quality in the Klamath River system generally improves appreciably as the river flows downriver from its source at the outflow from Upper Klamath Lake towards the estuary. This generally improving trend is evident in many water quality parameters including dissolved organic carbon (DOC), total phosphorus, and total nitrogen data obtained in recent years by a cooperative effort of the KHSA Monitoring Group[6] (see Figure 4.2-1 for example year 2012). This occurs because the river's source is Upper Klamath Lake, which is a large hypereutrophic lake that is nutrient-enriched and has massive recurrent algae blooms (ODEQ 2002, Kann and Welch 2005, Walker et al. 2012). The episodic declines (or "crashes") of the algae blooms result in the downstream release of large loads of nutrients and organic matter to the river during the late spring through fall. The result is that the quality of the water flowing from the lake is the "driver" that dictates water quality throughout the downstream system. The influence of the lake's seasonal discharges of large quantities of nutrients and organic matter on downstream river reaches can be dramatic, especially with respect 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. However, in addition to watershed/reservoir inflow treatment, there are several other categories of management techniques for water quality enhancements in reservoirs, including: (1) in-reservoir physical treatment techniques (e.g., mixing, circulation, oxygenation, drawdown); (2) in-reservoir chemical treatment techniques (e.g., phosphorus inactivation or settling agents, algaecides); and (3) in-reservoir biological treatment techniques (e.g., enhanced zooplankton grazing, selective fish removal) (Holdren et al. 2001, Cooke et al. 2005).

[6] The KHSA Monitoring Group consists of representatives from the North Coast Regional Water Quality Control Board; Oregon Department of Environmental Quality; U.S. Environmental Protection Agency, Region IX; Karuk Tribe; Yurok Tribe; PacifiCorp; and U.S. Bureau of Reclamation.

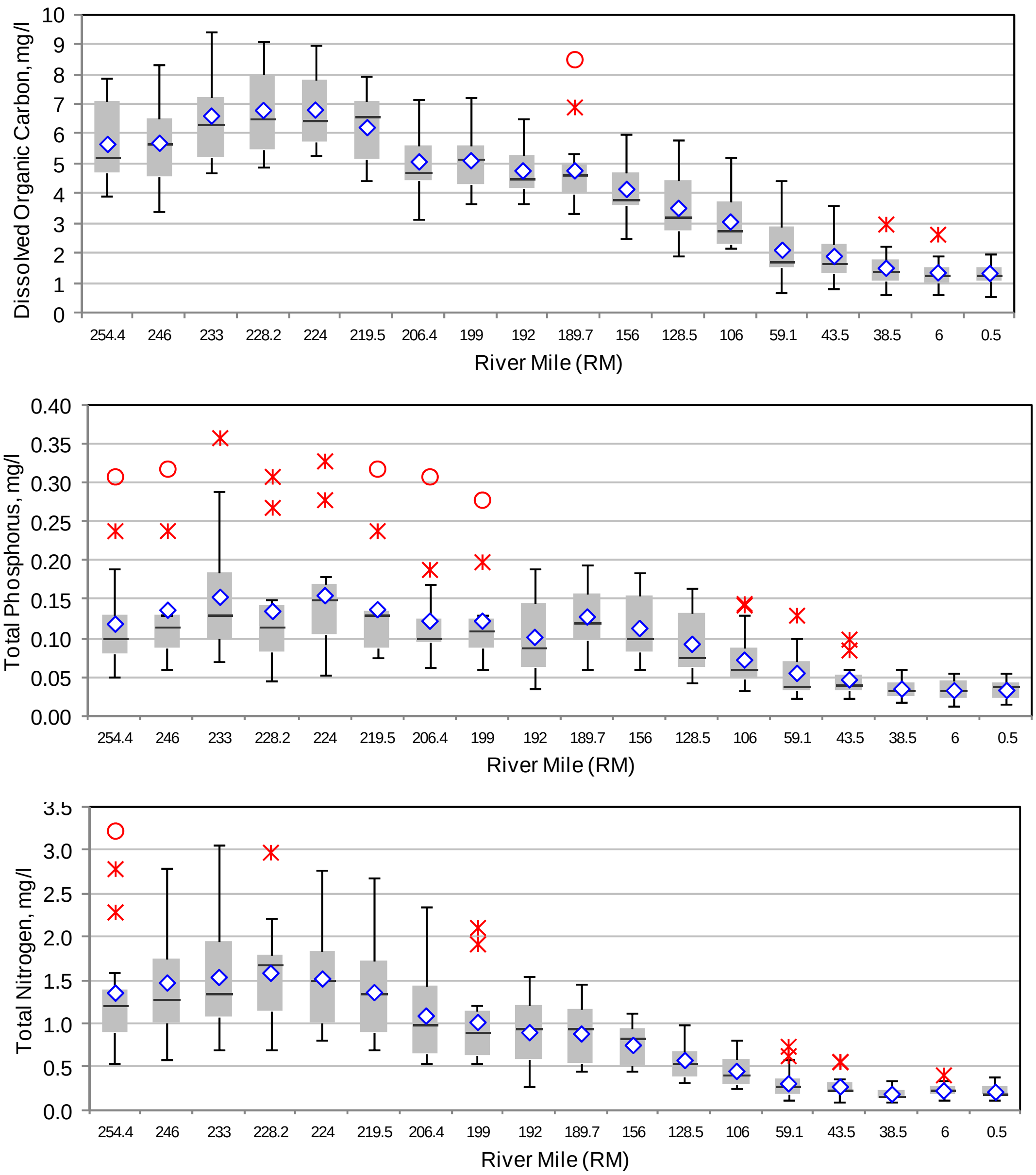


Figure 4.2-1. Box plots[7] of dissolved organic carbon (DOC), total phosphorus, and total nitrogen data obtained in 2012 at various sites[8] by a cooperative effort of the KHSA Monitoring Group. See Watercourse (2013) for more details.

Five dams on the upper Klamath River (i.e., Link River, Keno, J.C. Boyle, Copco No. 1, and Iron Gate) directly affect the travel time of water from Upper Klamath Lake to the estuary. The transit time of waters

[7] A box plot (also known as a box and whisker diagram) is a basic graphing tool that displays the median, range, and distribution of a data set. The bottom of each box is the 25th percentile, the top of the box is the 75th percentile, and the line in the middle is the 50th percentile or median. The vertical lines above and below each box (the “whiskers”) extend to maximum and minimum values to give additional information about the spread of data.

[8] The monitoring sites shown in the figure include RM 254.4: Link River dam, RM 246: Keno Reservoir at Miller Island, RM 233: Klamath River below Keno dam, RM 228.2: Klamath River above J.C. Boyle Dam, RM 226: J.C. Boyle Reservoir, RM 224: Klamath River below J.C. Boyle Dam, RM 219.5: Klamath River below USGS Gage, RM 206.4: Klamath River near Stateline, RM 199: Copco Reservoir, RM 192: Iron Gate Reservoir, RM 189.7: Klamath River below Iron Gate Dam, RM 156: Klamath River at Walker Bridge Road, RM 128.5: Klamath River below Seiad Valley, RM 106: Klamath River near Happy Camp, RM 59.1: Klamath River at Orleans, RM 43.5: Klamath River at Weitchpec, RM 38.5: Klamath River below Trinity River, RM 6: Klamath River near Klamath, and RM 0.5: Klamath River Estuary.

released from Upper Klamath Lake to the estuary (as well as water released from Reclamation's Klamath Project to the river between the lake and Keno dam) is about 1 to 2 months or more. If no dams were in place, transit time from Upper Klamath Lake (Link River dam) to the estuary would be about a week during typical summer periods and less during winter high flow events. The dams slow the travel time in the first 65 miles of the Klamath River, which allows settlement of particulate nutrients and processing of the large loads of nutrients and organic matter in the water from Upper Klamath Lake.

Upper Klamath Lake is a critical feature that impacts 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 2012 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, Karuk Tribe, Yurok Tribe 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

Upper Klamath Lake is upstream of the Project and is not affected by the Project's operations. PacifiCorp does not have control over lake levels or releases, which are directed by the Bureau of Reclamation. Nonetheless, 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. As described above, the quality of the water flowing from the lake is the "driver" that dictates water quality throughout the Klamath River.

Upper Klamath Lake is a large (121 mi2), shallow (mean depth about 8 feet at full pool) lake that is geologically old and classified as hypereutrophic (highly enriched with nutrients and supporting high abundance of suspended algae) (Johnson et al. 1985, ODEQ 2002). The lake is subject to wind mixing, and persistent physical or chemical stratification is not evident. A paleolimnological study by Eilers et al. (2001) revealed that Upper Klamath Lake has been a very productive lake for centuries, 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 the lake has apparently deteriorated substantially over the past several decades.

Excessive phosphorus loading linked to watershed development has been determined to be a key factor driving Upper Klamath Lake's hypereutrophy and the massive blooms of the blue-green algal species *Aphanizomenon flos-aquae* (cyanobacteria) that dominate the lake (Kann and Welch 2005, Walker et al. 2012). Phosphorus concentrations in the lake and its outflow (at Link River dam) are driven by the "external" phosphorus loading from the watershed and the "internal" loading caused from the cycling of phosphorus between the water column and bottom sediments (Kann 1998, Kann and Welch 2005, Walker et al. 2012). While the "internal" loads released from bottom sediments in early summer contribute to the massive algal blooms, these loads reflect antecedent external loads that are stored and recycled from the bottom sediments over long time frames (Walker et al. 2012).

Low dissolved oxygen and high pH values have been linked to high algal productivity in Upper Klamath Lake (Kann and Walker 2001, Walker 2001, ODEQ 2002, Hoilman et al. 2008, Kannarr et al. 2010, Eldridge et al. 2012). Chlorophyll *a* concentrations exceeding 200 μg/L are frequently observed in the summer months (Kann and Smith 1993, ODEQ 2002, Hoilman et al. 2008, Kannarr et al. 2010, Eldridge et al. 2012). Algal blooms in the lake 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 Upper Klamath Lake in 1998 by ODEQ. ODEQ subsequently established a TMDL for the lake in May 2002 that seeks to achieve a 40 percent reduction of total phosphorous loading to the lake (ODEQ 2002).

4.2.2 Link River

The Link River reach is approximately 1.2 miles in length and extends to the headwaters of Keno reservoir (Lake Ewauna). The upstream boundary of this reach is Link River dam (RM 254.6), which regulates the level of Upper Klamath Lake and controls releases into the Link River and the East Side and West Side hydroelectric developments. Flow releases into Keno Reservoir (Lake Ewauna) from Link River dam also provide water supply for Reclamation's Klamath Project, although a significant source of Reclamation's water supply is provided by the A-Canal, which is upstream of Link River dam. Pursuant to an agreement with Reclamation, PacifiCorp operates Link River dam at Reclamation's direction. Reclamation directs operations of the dam in accordance with the most recent Biological Opinion for operation of Reclamation's Klamath Project relating to the listed sucker species in Upper Klamath Lake and coho salmon in the Klamath River below Iron Gate dam (NMFS and USFWS 2013). Flow releases at Link River dam are generally managed to provide sufficient flow to maintain required releases from PacifiCorp's Iron Gate dam consistent with the biological opinion.

4.2.2.1 Hydrology

Because of Link River's short 1.2-mile length, water travels through this reach in a short time—about 1 hour. There are no major tributaries or withdrawals from the reach proper. Reclamation is responsible for management of flow volumes in the upper Klamath River in accordance with the most recent Biological Opinion for operation of Reclamation's Klamath Project relating to the listed coho salmon in the Klamath River below Iron Gate dam (NMFS and USFWS 2013). This includes flows that both enter (from Upper Klamath Lake at Link River dam at RM 254) and exit (from Iron Gate dam at RM 190.1) the area occupied by PacifiCorp's Project developments. Reclamation also manages Upper Klamath Lake elevations to meet contractual irrigation demands of Reclamation's Klamath Project and applicable requirements of the most recent Biological Opinion relating to the listed sucker species in Upper Klamath Lake (NMFS and USFWS 2013).

Link River dam also is the point of water diversion for the East Side and West Side developments. The East Side and West Side power plants, transmission lines, and associated water conveyance systems are owned and operated by PacifiCorp. As described in Section 2.7.6.2 above, PacifiCorp has implemented a substantial shutdown of operations at the East Side and West Side Developments in accordance with PacifiCorp's HCP for the Lost River sucker and shortnose sucker (PacifiCorp 2013) and the associated Incidental Take Permit (ITP) issued by USFWS in February 2014. Further, as noted in section 2.2 above, PacifiCorp proposes to eventually decommission the East Side and West Side developments and to remove them from the FERC-licensed Project. Until decommissioning, the East Side and West Side facilities would remain in place, and the water conveyance features will remain watered up to maintain the integrity of the facilities during the interim and to continue to provide for small irrigation demands from adjacent landowners.

4.2.2.2 Water Temperature

The quality of water in the Link River reach is dominated by Upper Klamath Lake, and thus water temperature conditions in Link River are similar to those in the lake. Over the course of a year, releases at Link River dam range in temperature from near zero degrees Celsius in winter periods to about 25°C in summer periods (see Figure 4.2-2 for example year 2012). Because Klamath Lake is shallow, the release temperatures at Link River dam generally reflect local meteorological conditions.

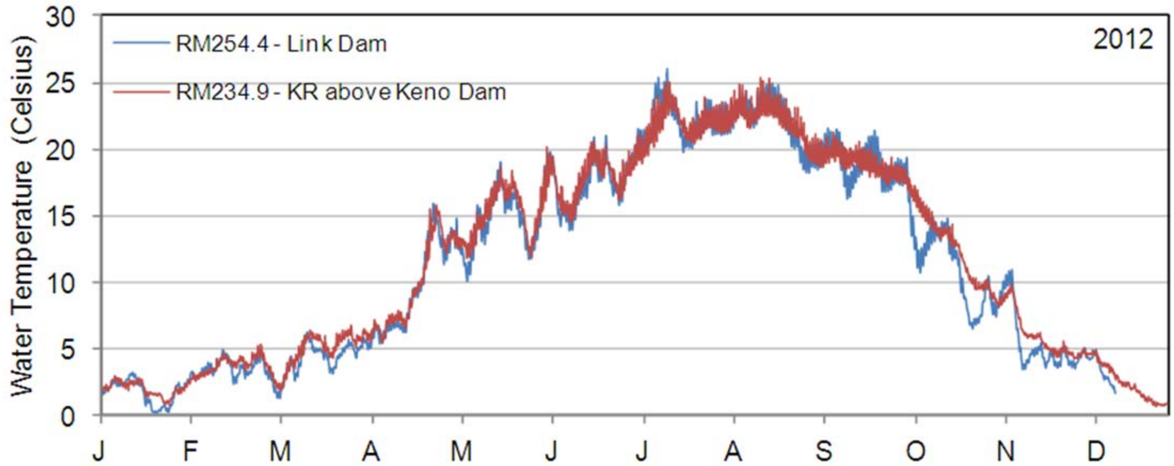


Figure 4.2-2. Annual trend of water temperatures during 2012 measured in the upper Klamath River at Link River dam and Klamath River above Keno dam (near surface). Continuous data was collected using datasondes.

4.2.2.3 Nutrients and Algal Production

Levels of phosphorous and nitrogen at Link River dam are a direct result of the nutrient and algal dynamics that occur within Upper Klamath Lake. Figure 4.2-3 shows yearly (i.e., 1992 to 2010) flow-weighted mean (FWM) concentrations of total phosphorus and total nitrogen in the outflow from Upper Klamath Lake (equivalent to Link River dam) as determined by Walker et al. (2012). The year-to-year variability in FWM concentrations of total phosphorus and total nitrogen in the outflow from the lake primarily reflects yearly variability in hydrology (i.e., flows in and out of the lake). Walker et al. (2012) indicate that outflow loads of total phosphorus from the lake are similar in magnitude to the lake's inflow loads, but suggest that there is a one-year lag in the response of the phosphorus loads in the outflow to annual variations in the inflow loads. This apparent lag likely reflects nutrient retention and recycling processes within the lake as well as the lengthy residence time within the lake, which is approximately 6 months at average flows. Walker et al. (2012) also indicate that outflow loads of total nitrogen from the lake are more than three-fold higher in magnitude than the lake's inflow loads, reflecting the substantive effects of the large blooms of *Aphanizomenon*, which is a blue-green algal species capable of fixing atmospheric nitrogen.

Figure 4.2-3 indicates that the overall FWM mean concentration of total phosphorus in the outflow from Upper Klamath Lake is on the order of 110 ppb (or µg/L). As the upstream "boundary" concentration of source flows to the Klamath River system, this concentration of total phosphorus exceeds by two-fold the threshold level of 50 ppb (or µg/L) reported by Welch (1992) for nutrient enrichment impairment of rivers. This concentration exceeds by nearly four-fold the instream total phosphorus target of 25 µg/L derived in the Upper Klamath Lake TMDL (ODEQ 2002) for the Link River location. ODEQ (2010) predicted that this instream total phosphorus target at Link River dam would allow for compliance with water quality standards in the Klamath River with the attainment of nutrient reductions consistent with the TMDL allocations.

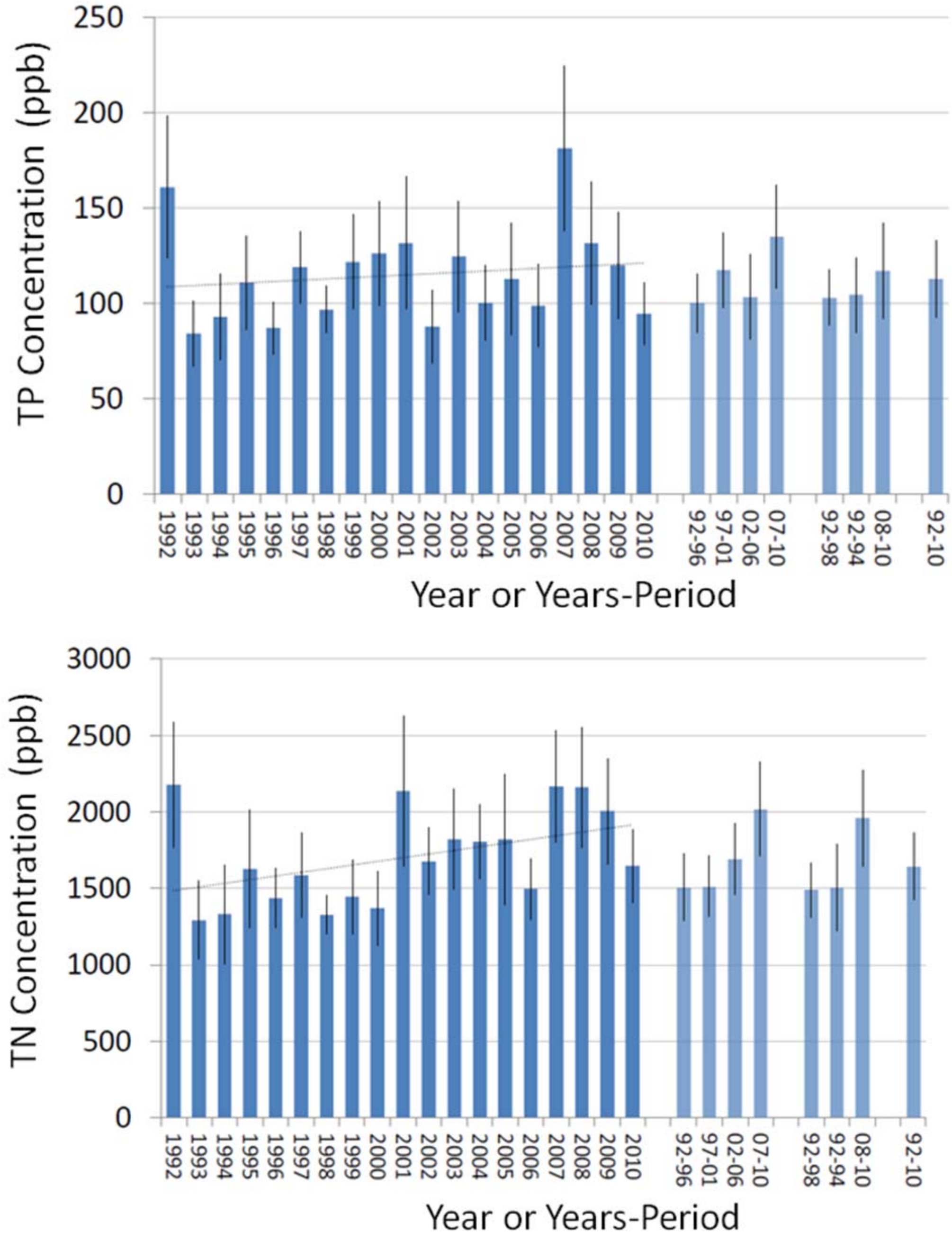


Figure 4.2-3. Total phosphorous (upper plot) and total nitrogen (lower plot) concentrations, in parts per billion (ppb; also equivalent to µg/L) at the outflow from Upper Klamath Lake (equivalent to Link River dam) as flow-weighted mean concentrations by year or yearly periods. Source of data for these plots is Walker et al. (2012).

Figure 4.2-4 shows monthly and seasonal FWM concentrations of total phosphorus and total nitrogen in the outflow from Upper Klamath Lake (equivalent to Link River dam) as determined by Walker et al. (2012). These plots indicate that concentrations of total phosphorous and total nitrogen vary considerably throughout the year in the Upper Klamath Lake outflow at Link River dam, largely 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 Upper Klamath Lake. 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.

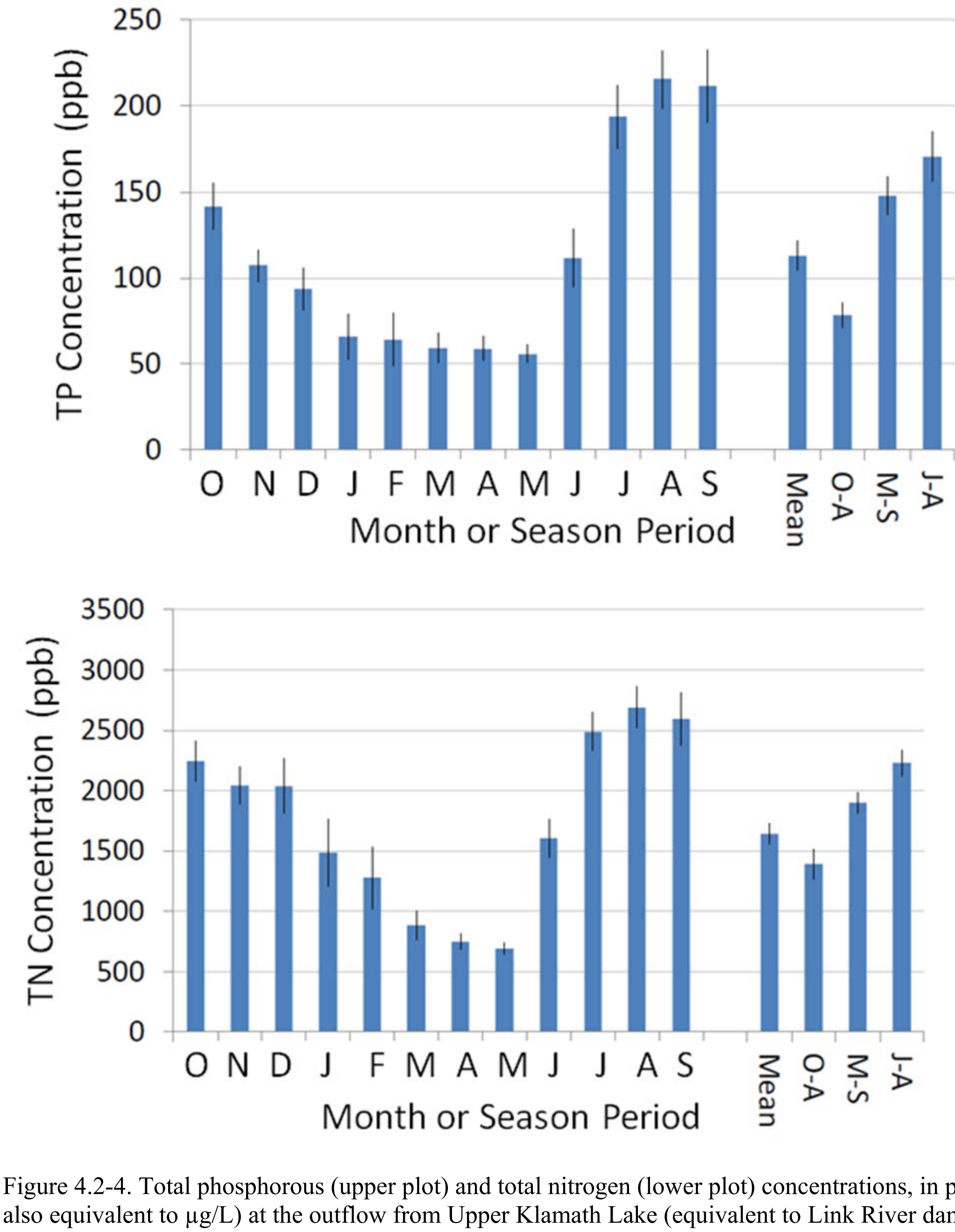


Figure 4.2-4. Total phosphorous (upper plot) and total nitrogen (lower plot) concentrations, in parts per billion (ppb; also equivalent to µg/L) at the outflow from Upper Klamath Lake (equivalent to Link River dam) as flow-weighted mean concentrations by month or seasonal periods. Source of data for these plots is Walker et al. (2012).

Overall, the nutrient load from Upper Klamath Lake is largely unchanged in the short Link River reach. The large loads and concentrations of organic matter and nutrients reach Lake Ewauna and Keno reservoir (as discussed in the section below) at essentially the same levels as released from the outflow of Upper Klamath Lake. Phytoplankton that wash out of Upper Klamath Lake 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 in Link River to accommodate fluctuating water demands within the downstream Keno Reservoir 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 results in a variable wetted channel that may limit algae growth.

4.2.2.4 Dissolved Gases

Dissolved oxygen conditions in the Upper Klamath Lake outflow at Link River dam vary throughout the year (see Figure 4.2-5 for example year 2012). During winter months when temperatures and primary production are low, the dissolved oxygen levels remain close to saturation[9] at about 10 to 12 milligrams per liter (mg/L). 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 4 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. Field data suggest that conditions may be sufficient for phytoplankton to continue to photosynthesize and respire in portions of this reach, as indicated by the larger daily diurnal range during the warmer period of the year when primary production is highest (Figure 4.2-5).

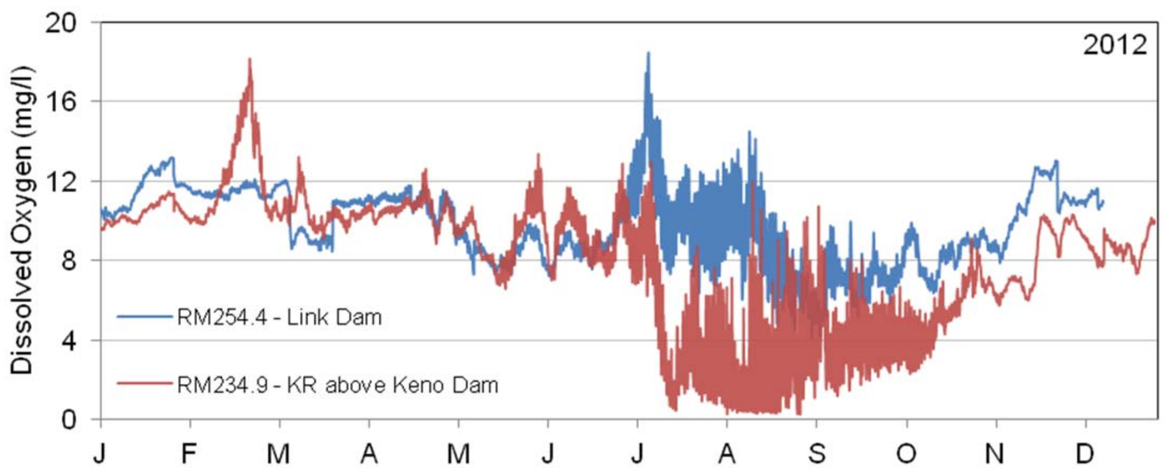


Figure 4.2-5. Annual trend in dissolved oxygen during 2012 as measured in the upper Klamath River at Link River dam and Klamath River above Keno dam (near surface). Continuous data was collected using datasondes.

4.2.2.5 Alkalinity and pH

Generally, the alkalinity of Upper Klamath Lake 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 as well as changes in pH can lead to increased toxicity of certain constituents (e.g., ammonia) (Colt et al. 1979, EPA 1984). pH values typically range from 7.0 to 8.0 at Link River dam during winter periods, while during the warmer seasonal periods when significant primary production occurs pH values typically

[9] 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).

range from 8.0 to 10.0 (see Figure 4.2-6 for example year 2012). Values above 8.5 to 9.0 can lead to ammonia toxicity.

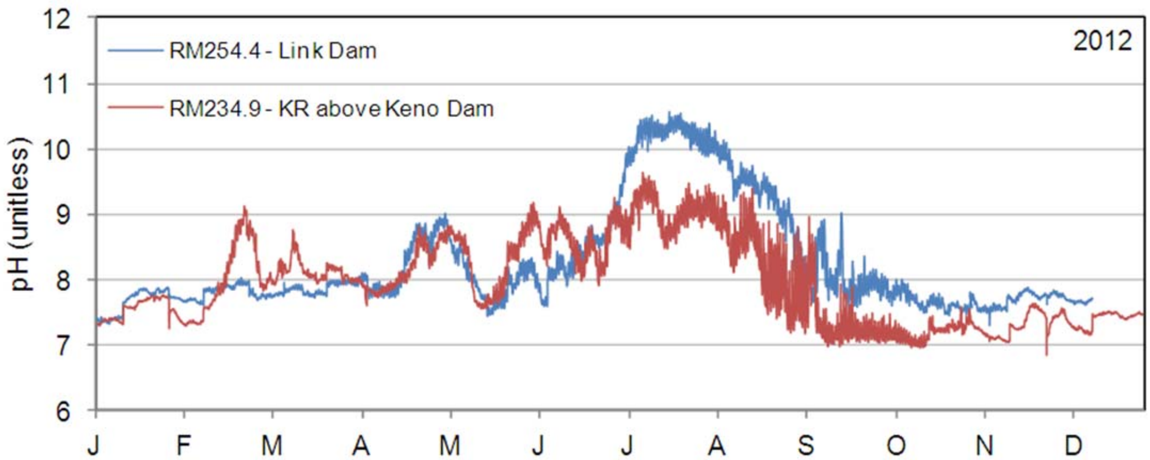


Figure 4.2-6. Annual trend in pH during 2012 as measured in the upper Klamath River at Link River dam and Klamath River above Keno dam (near surface). Continuous pH data was collected using datasondes.

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 Upper Klamath Lake to Keno reservoir with little or no change.

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 2005a). Municipal, industrial, and agricultural activities are located along this reach (ODEQ 1995, ODEQ 2010).

Currently, Keno reservoir experiences severe water quality impairment. These impairments include persistent summer anoxia for several miles of the river caused primarily by the oxygen demand of the large organic matter loads from Upper Klamath Lake (Sullivan et al. 2011, Sullivan et al. 2013). 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.

4.2.3.1 Hydrology

PacifiCorp operates Keno dam pursuant to a contract with Reclamation. The contract requires PacifiCorp to maintain Keno reservoir at elevations between 4085.0 and 4086.5 feet whenever Reclamation is diverting water to Reclamation's Klamath Project. From the upper bounds to the lower bounds of these elevations is the equivalent of 3,700 acre-feet, with total storage of approximately 16,500 acre-feet. The contract also requires PacifiCorp to operate Keno dam to facilitate the return of used irrigation water into the river at the Klamath Straits Drain (up to 300 cfs) and the Lost River diversion channel (up to 3,000 cfs). Current elevation constraints at Keno dam to provide water elevations suitable for diversion and drainage by adjacent landowners and Reclamation require that the reservoir be kept at a nearly constant water elevation, with the exception of some allowance for unexpected flow variance.

One of the critical features of this reach is Keno dam, which impounds the Klamath River to form Keno reservoir, which has a surface area of 2,475 acres. The result is a long (20-mile), relatively shallow reservoir with a residence time of approximately a week under typical spring through fall flow rates, and longer under low flow conditions. 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 the water surface elevation of Keno reservoir is kept relatively constant most of the time, inflows must match outflows. It follows that flows through Keno dam largely mimic those into Keno reservoir, namely releases from Upper Klamath Lake plus the net Reclamation canal withdrawals and returns into Keno reservoir. A result of such operations is that the river below Keno dam may fluctuate to keep Keno reservoir elevation constant; however, this objective is usually achieved by managing releases from Link River dam.

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 about 25°C (see Figure 4.2-2 for example year 2012) and are at or near equilibrium water temperatures,[10] reflecting local meteorological conditions and the fact that Upper Klamath Lake is generally at or near equilibrium water temperature conditions. The flow 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. Therefore, these inputs do not affect water temperature conditions in the reservoir appreciably. The reservoir freezes in some winters. Water temperatures of reservoir inflows are similar to water temperatures of reservoir outflows.

4.2.3.3 Nutrients and Algal Production

Nutrient conditions vary throughout the year in response to inputs from Upper Klamath Lake and the role of primary production. Organic matter is a primary product from the lake 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 this organic matter are passed downstream. Sullivan et al. (2010) report that large loads of particulate organic matter emanating from the lake are an important component of oxygen demand in the Lake Ewauna/Keno reservoir reach of the Klamath River. Sullivan et al. (2010) measured large oxygen demand values in the reach, including maximum 5-day BOD and 30-day BOD values of 26.5 and 55.4 mg/L, with minimums of 4.2 and 13.6 mg/L, respectively. The large oxygen-demand problem in this reach has been well-documented previously. In 1955, the State of Oregon (Oregon State Sanitary Authority et al. 1955) concluded that the large nutrient load and oxygen demand from the lake outflow 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” (“natural causes” referring to algae bloom materials).

The decay and settling of algae and particulate organic matter in the Lake Ewauna/Keno reservoir reach of the Klamath River has important implications for nutrients (Wetzel 2001, Sullivan et al. 2010). This organic matter, which may take on one of several forms (labile, refractory, particulate, and/or dissolved), also contains organic forms of nutrients (N and P). These nutrients are transported downstream and upon decay of the organic matter are released and available for uptake by local phytoplankton and benthic algae

[10] Equilibrium water temperature is the temperature that would be established if a water surface were exposed to constant (average) meteorological conditions (Martin and McCutcheon 1999). The equilibrium water temperature corresponds to the condition with no net heat exchange between the air and water. 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.

populations (Elwood et al. 1983, Sullivan et al. 2010, Sullivan et al. 2011). 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) (Deas 2008).

In addition to the organic matter and nutrient loading from Upper Klamath Lake, the agricultural return flows from the Reclamation's Klamath Project also contribute loads (although lesser) of nutrients, total dissolved solids, and BOD (Deas 2008, ODEQ 2010). Return flows from other private agricultural diversions have not been explicitly quantified, but the quality is presumably similar to Reclamation's Klamath Project 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 (ODEQ 2010).

Under anoxic conditions, internal nutrient cycling from the sediments has been identified (Eilers and Raymond 2003, 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 (Sullivan et al. 2011).

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 Upper Klamath Lake. Maximum concentrations of chlorophyll *a* at Link River can reach 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 (2008) completed mass balance estimates on reach inflows and outflows for total nutrients. PacifiCorp (2008) stated that these analyses were not comprehensive mass balances accounting for all inflow and outflow within the reach. Rather, the analyses assumed that loads at the top of the reach and bottom of the reach, as well as internal processes, were implicitly included. Figure 4.2-7 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.

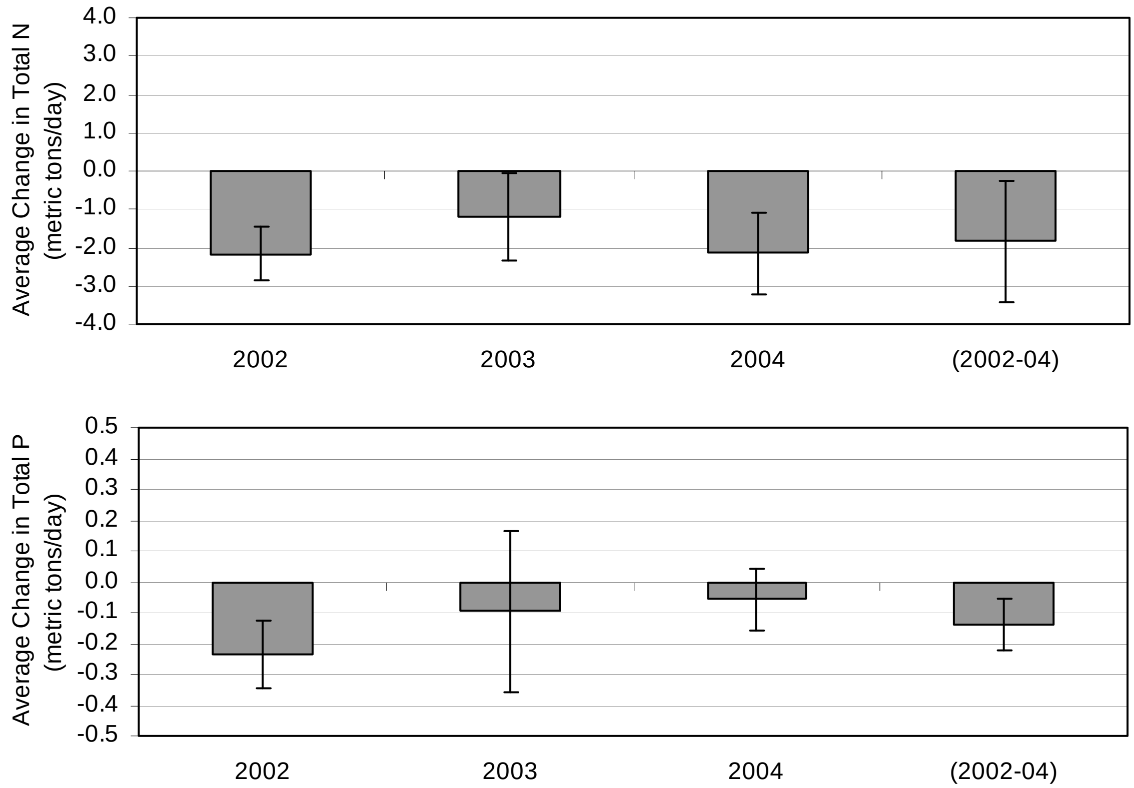


Figure 4.2-7. Annual change in total nitrogen (top plot) and total phosphorous (bottom plot), in metric tons/day, between Link River above Lake Ewauna and Klamath River below Keno dam, 2002, 2003, 2004, and 2004-2004 (positive represents increase, negative represents decrease). The 90 percent confidence intervals are represented by error bars.

Additional information on nutrient conditions in the vicinity of the Project, including in Keno reservoir, 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), the report titled "Causes and Effects of Nutrient Conditions in the Upper Klamath River" (PacifiCorp 2006), and various annual water quality monitoring reports (Raymond 2008a, Raymond 2009a, Raymond 2010a, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013, Deas 2008). As identified nearly 60 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 (see Figure 4.2-5 for example year 2012). Winter conditions result in near saturation values for dissolved oxygen at about 10 to 12 milligrams per liter (mg/L). However, summer and fall values are typically well under saturation and may be near zero (i.e., anoxic). The source of these sub-saturated or anoxic dissolved oxygen conditions is the large oxygen demand imparted on this reach by the large organic matter influx from Upper Klamath Lake (Sullivan et al. 2011, Sullivan et al. 2012, Sullivan et al. 2013). 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. Low dissolved oxygen concentrations persist well into October and may extend into November. Figure 4.2-8 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 (Sullivan et al. 2011, Sullivan et al. 2012, Sullivan et al. 2013). Conditions below Keno dam are generally improved due to reaeration of releases from the dam, where the configuration of radial gates and the sluice discharge from the dam can act to reaerate releases to some degree, and from natural mechanical aeration in the high-gradient 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 Upper Klamath Lake.

4.2.3.5 Alkalinity and pH

Alkalinity varies seasonally in this reach 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 Link River dam, with values ranging from 7.0 to 9.0 in winter and between about 8.0 and 9.5 in summer (see Figure 4.2-6 for example year 2012). One deviation from this pattern is that during severe anoxia, pH values may fall back to near 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 modest, with inflow temperatures similar to outflow temperatures. Dissolved oxygen conditions can be low or at times absent (anoxic) within the impoundment, particularly during summer. As such,, in the summer and early fall, dissolved oxygen conditions in the Keno reservoir reach are notably lower than in Link River (Figure 4.2-5). The overall effect of Keno reservoir on BOD and total suspended solids is reduced concentrations of each below Keno dam as compared to Link River due to settling and processing that occurs with the reservoir. Specific conductance and alkalinity both show notable increases in this reach Throughout the summer and early fall, pH is generally similar or higher at Link River dam than in the Keno reservoir reach (Figure 4.2-6).

The Keno reservoir reach experiences highly variable, complex water quality conditions in response to hydrology (including water resources development), meteorology, and impaired water quality from Upper Klamath Lake. 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 has contributed to extensive fish die-offs both in the past (Wee and Herrick 2005, PacifiCorp 2006), and relatively recently in 2005 (R. Piaskowski, USBR fish biologist, pers. comm.). Overall, these findings suggest that this reach is actively processing organic matter (with some associated conversion of nutrient forms), but only modestly retains or reduces total nutrient levels in the river under typical conditions.

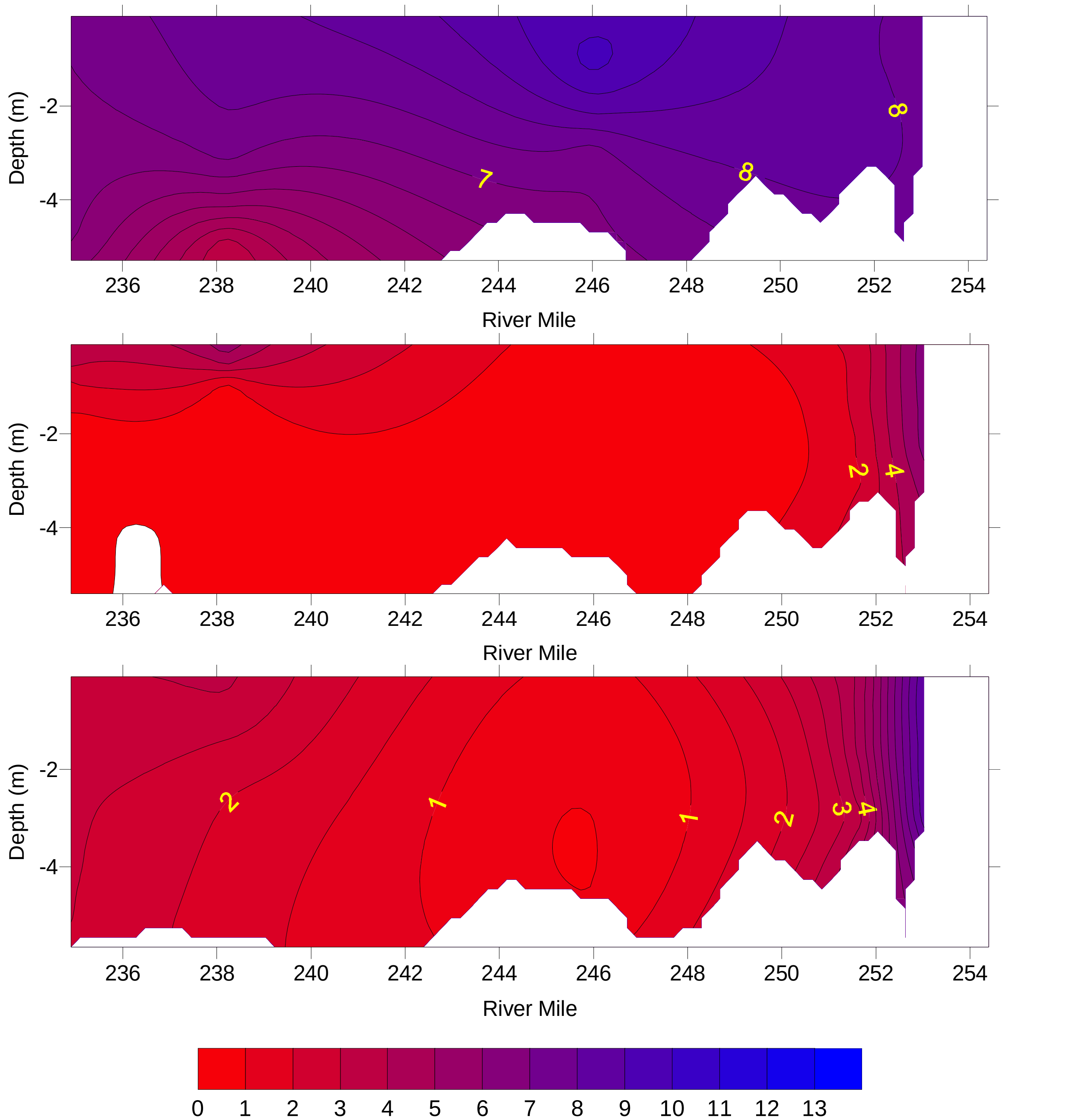


Figure 4.2-8. Dissolved oxygen isopleths (in mg/L) in Keno reservoir on May 3, 2005 (top plot), July 26, 2005 (middle plot), and October 18, 2005 (bottom plot). Data obtained from U.S. Bureau of Reclamation.

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 a modest diurnal variation 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 during the warmer period of the year 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 water temperature.

4.2.4.3 Nutrients and Algal Production

A comparison of nutrient data obtained at Keno dam and just above J.C. Boyle reservoir suggests that overall total phosphorus and total nitrogen are almost unchanged through the reach (Figure 4.2-9). However, it is apparent that processing[11] occurs within the reach that produces changes of inorganic or organic nutrient forms (Deas 2008). Changes in the concentrations of inorganic nitrogen forms (i.e., ammonia and nitrate+nitrite) are particularly evident through the reach. The waters released from Keno dam are relatively high in ammonia and low in nitrate+nitrite during summer months. These waters are subjected to nitrification during transit through the reach, leading to notably higher concentrations of nitrate+nitrite and lower concentrations of ammonia at the downstream end of the reach above J.C. Boyle reservoir (Deas 2008).

Changes in the concentrations of inorganic phosphorus also are evident throughout the reach, indicated by the increase in orthophosphate concentrations between Keno Dam to the site above J.C. Boyle reservoir (Figure 4.2-9). Phosphorus bound in organic matter from upstream sources (dissolved and particulate) probably undergoes some level of conversion (e.g., oxidation of organic matter) yielding the observed increase in orthophosphate (Deas 2008).

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 a relatively high light extinction, 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 (PacifiCorp 2004e, PacifiCorp 2008a).

[11] Processing could include sequestration of nutrients in algal biomass, denitrification, burial, desiccation, atmospheric deposition, conversion, senescence, or re-entrainment and erosion (Deas 2008).

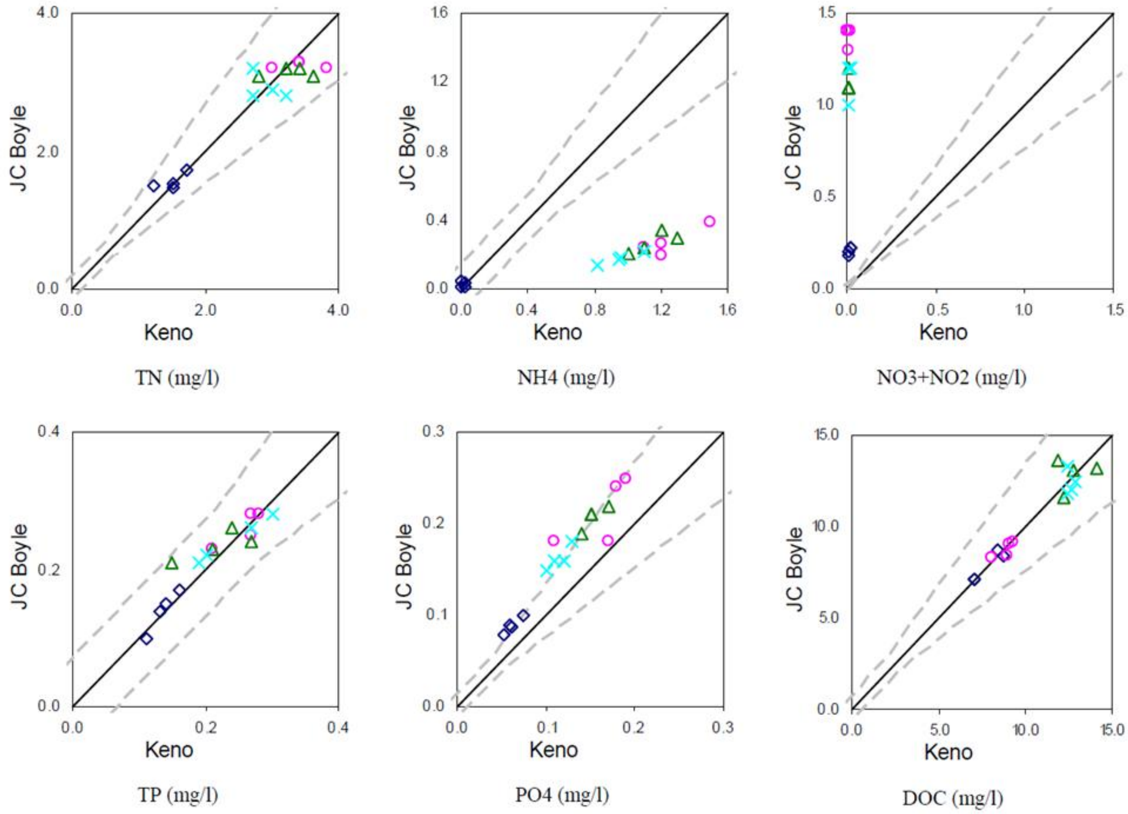


Figure 4.2-9. Changes in concentrations in the Keno reach of the Klamath River between Keno dam and J.C. Boyle reservoir in total nitrogen (TN), ammonia (NH4), nitrate-nitrite (NO3+NO2), total phosphorus (TP), orthophosphate (PO4), and dissolved organic carbon (DOC). The 1:1 line in each graph denotes a line of equivalent concentration at the upstream and downstream locations. Values below the line indicate a decrease in that constituent through the reach, and values above the line indicate an increase in that constituent through the reach. See Deas (2008) for more details.

4.2.4.4 Dissolved Gasses

Due to the steepness of this reach and the associated mechanical reaeration, dissolved oxygen concentrations generally improve in this reach of the river between Keno dam (RM 233) and above J.C. Boyle reservoir (RM 228), approaching equilibrium conditions with the atmosphere (see Figure 4-2-10 for plots of dissolved oxygen concentration and saturation for example year 2009). However, dissolved oxygen concentrations in this reach of the river are generally not completely (100 percent) saturated during the summer period, with values around 7 mg/L. This sub-saturation condition are typically associated with the large organic load from upstream sources in Upper Klamath Lake and Keno reservoir (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008a). 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 reach of the river between Keno dam (RM 233) and above J.C. Boyle reservoir (RM 228) (see Figure 4.2-11 for plots of alkalinity and pH values for example year 2009). pH generally shows a seasonal reduction, with values at the lower end of the reach above J.C. Boyle reservoir (RM 228) often less than just below Keno dam (RM 233) during the summer (Figure 4.2-11). 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 mechanical reaeration in the reach.

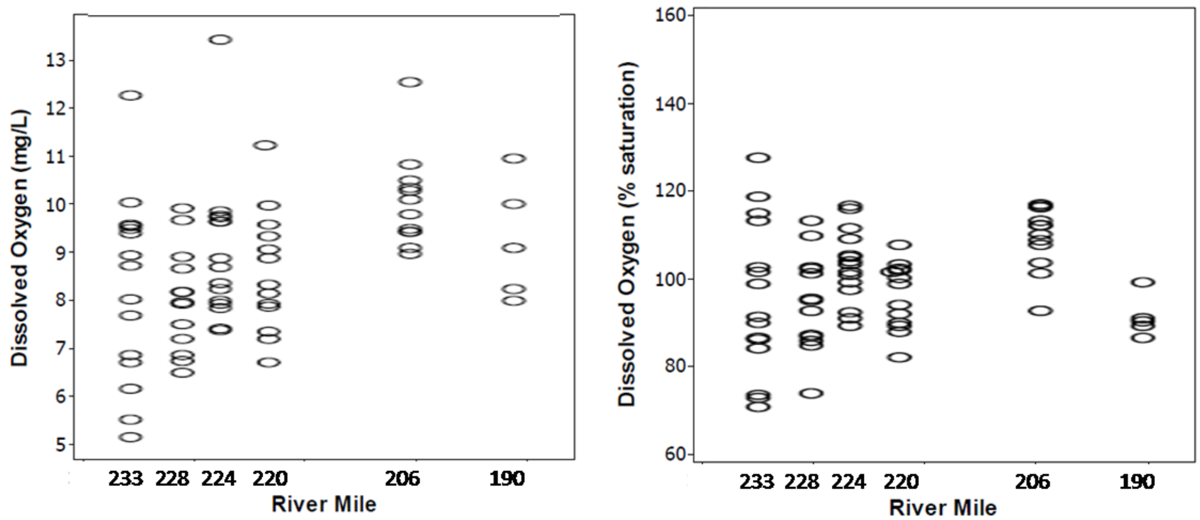


Figure 4.2-10. Dissolved oxygen values measured during 2009 in the Klamath River below Keno dam (RM 233), above J.C. Boyle reservoir (RM 228), below J.C. Boyle dam (RM 224), below J.C. Boyle powerhouse (RM 220), above Copco reservoir near Shovel Creek (RM 206), and below Iron Gate dam near the Hatchery bridge (RM 190). See Raymond (2009) for more details.

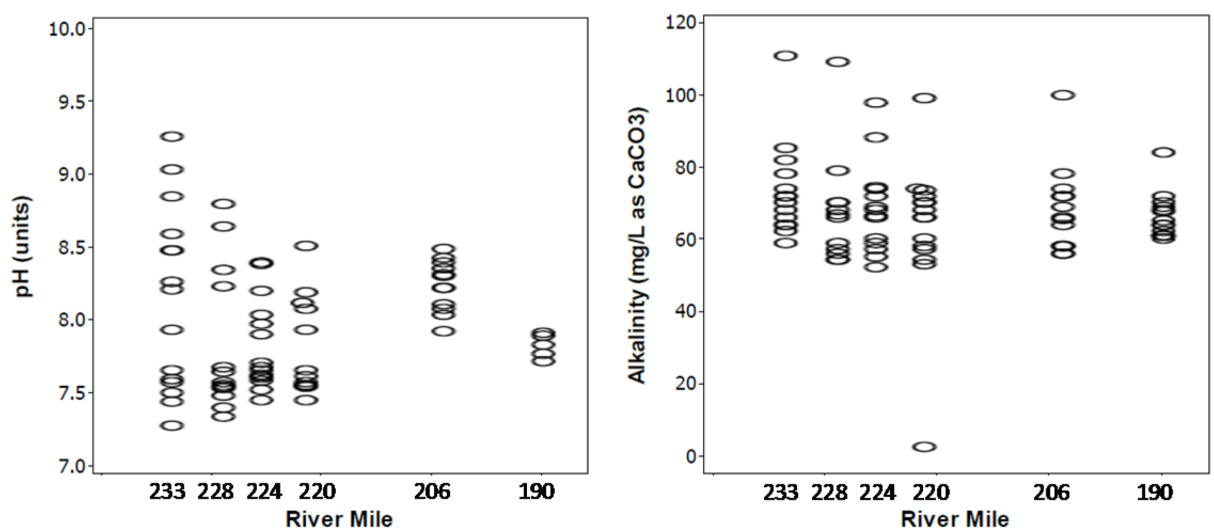


Figure 4.2-11. Alkalinity and pH values measured during 2009 in the Klamath River below Keno dam (RM 233), above J.C. Boyle reservoir (RM 228), below J.C. Boyle dam (RM 224), below J.C. Boyle powerhouse (RM 220), above Copco reservoir near Shovel Creek (RM 206), and below Iron Gate dam near the Hatchery bridge (RM 190). See Raymond (2009) for more details.

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, including water 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 (Deas 2008). 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 a variable flow regime, substrate, and high velocities also play important roles in this reach, further limiting benthic algae production (Peterson 1996, Kirk 1994, Raymond 2008, Raymond 2009, Raymond 2010).

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) (Deas 2008, Kalff 2002, Wetzel 2001). 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, total nutrient concentrations are almost unchanged (Deas 2008).

4.2.5 J.C. Boyle Reservoir

J.C. Boyle reservoir, formed by J.C. Boyle dam, primarily serves to divert a portion of river flows to the J.C. Boyle powerhouse (RM 220.4) for generation and to provide instream flow releases to the J.C. Boyle bypass reach (from J.C. Boyle dam to the J.C. Boyle powerhouse as described below in Section 4.2.6). The J.C. Boyle reservoir 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). J.C. Boyle reservoir has a total storage capacity of approximately 3,500 acre-feet, a surface area of 420 acres, and the maximum depth is about 40 feet (see Table 3.1-1). 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 (see Table 3.1-1). The annual flow is increased slightly due to watershed contributions, predominately from Spencer Creek. If and when peaking operations occur, the water level in J.C. Boyle reservoir can fluctuate 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 are typically 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 there are spill releases at the dam.

4.2.5.2 Water Temperature

The short residence time, hydropower operations, and modest depth (maximum depth is approximately 40 feet) of J.C. Boyle reservoir prevent the development of persistent, seasonal thermal stratification driven by solar heating of the reservoir (see upper left plot in Figure 4.2-12 for example year 2009). However, a slight temperature gradient during summer may occur in the reservoir due to thermal loading and 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.

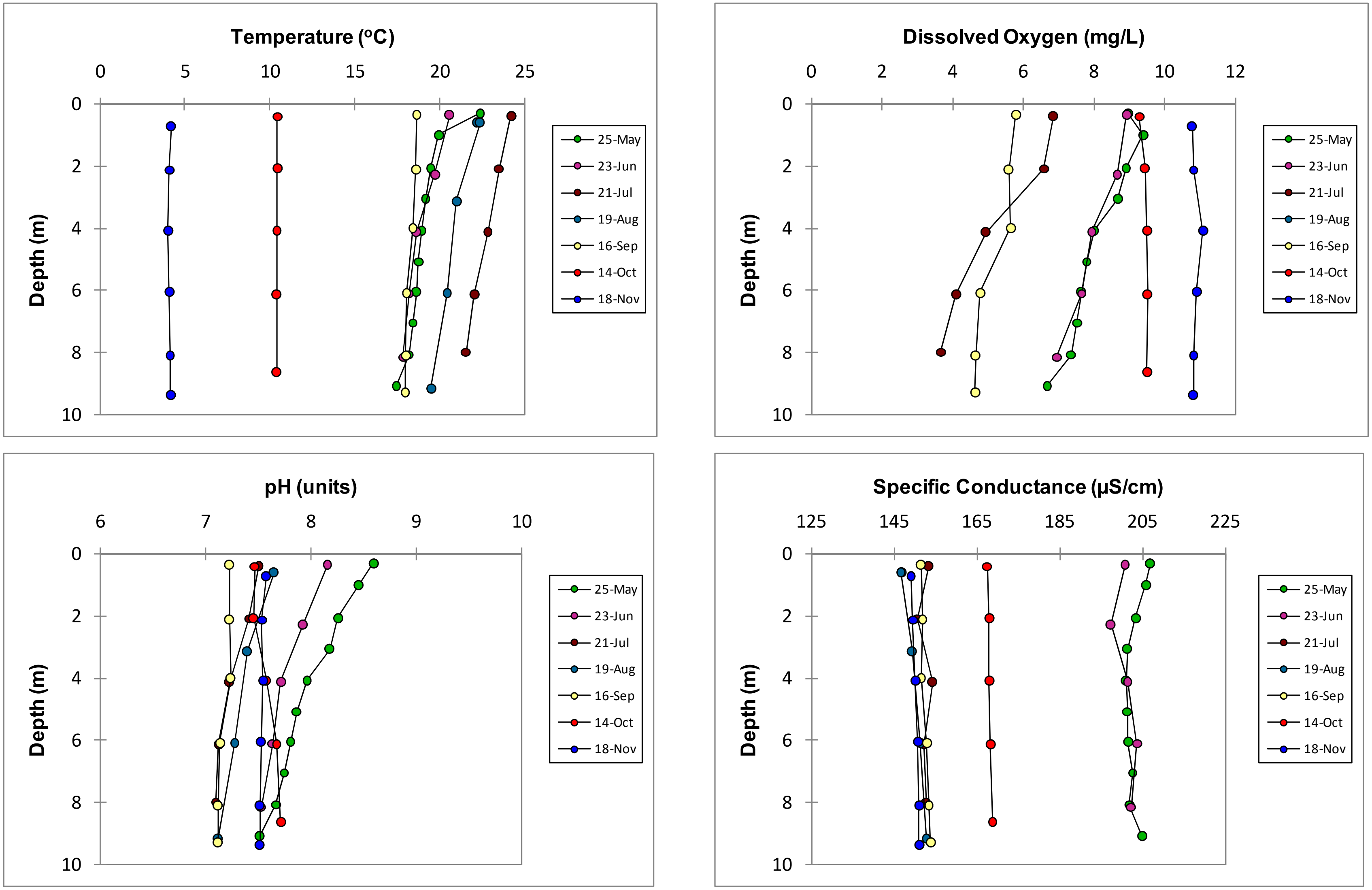


Figure 4.2-12. Vertical profile measurements of water temperature, dissolved oxygen, pH, and specific conductance in J.C. Boyle reservoir in 2009. See Raymond (2010) for more details.

4.2.5.3 Nutrients and Algal Production

The total nutrient concentrations in J.C. Boyle reservoir's outflowing waters are often similar to those in inflowing waters. Total nitrogen is similar between inflow and outflow, but there are times when inflow concentrations are higher than outflow and vice versa (for example, see lower plot in Figure 4.2-1 for site at RM 228.2 [above J.C. Boyle reservoir] compared to site at RM 224 [below J.C. Boyle reservoir]). In addition, the inflow and outflow concentrations for total inorganic nitrogen are often unchanged. However, monitoring data indicate that nitrate concentrations are generally slightly lower in release waters than reservoir inflows, while ammonia concentrations are generally slightly higher, indicating some conversion of these inorganic nitrogen forms as water flows through the reservoir (PacifiCorp 2004e, PacifiCorp 2006, Raymond 2008a, Raymond 2009a, Raymond 2010a). Additional information on un-ionized ammonia conditions in J.C. Boyle reservoir is provided in Section 5.9.3

Total phosphorus is also similar between inflow and outflow, but there are times when inflow concentrations are higher than outflow and vice versa (for example, see middle plot in Figure 4.2-1 for site at RM 228.2 [above J.C. Boyle reservoir] compared to site at RM 224 [below J.C. Boyle reservoir]). Orthophosphate concentrations are quite similar between reservoir inflows and outflows (PacifiCorp 2004e, PacifiCorp 2006, Raymond 2008a, Raymond 2009a, Raymond 2010a). Dissolved organic carbon observations suggest that inflow and outflow concentrations are also generally similar (for example, see top plot in Figure 4.2-1 for site at RM 228.2 [above J.C. Boyle reservoir] compared to site at RM 224 [below J.C. Boyle reservoir]).

To estimate nutrient retention (reduction) in J.C. Boyle reservoir, PacifiCorp (2008) completed mass balance estimates on reservoir inflows and outflows for total nutrients. Figure 4.2-13 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 (PacifiCorp 2006). 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), the report titled "Causes and Effects of Nutrient Conditions in the Upper Klamath River" (PacifiCorp 2006), and various annual water quality monitoring reports (Raymond 2008a, Raymond 2009a, Raymond 2010a, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013, Deas 2013).

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 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 (Raymond 2008b, Raymond 2009b, Raymond 2010b). Phytoplankton standing crop is typically higher in March, decreases in April into June, and increases to an annual peak in August. Biovolume and chlorophyll *a* values typically decrease considerably in September, but can 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 at some level 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 Upper Klamath Lake and Keno reservoir.

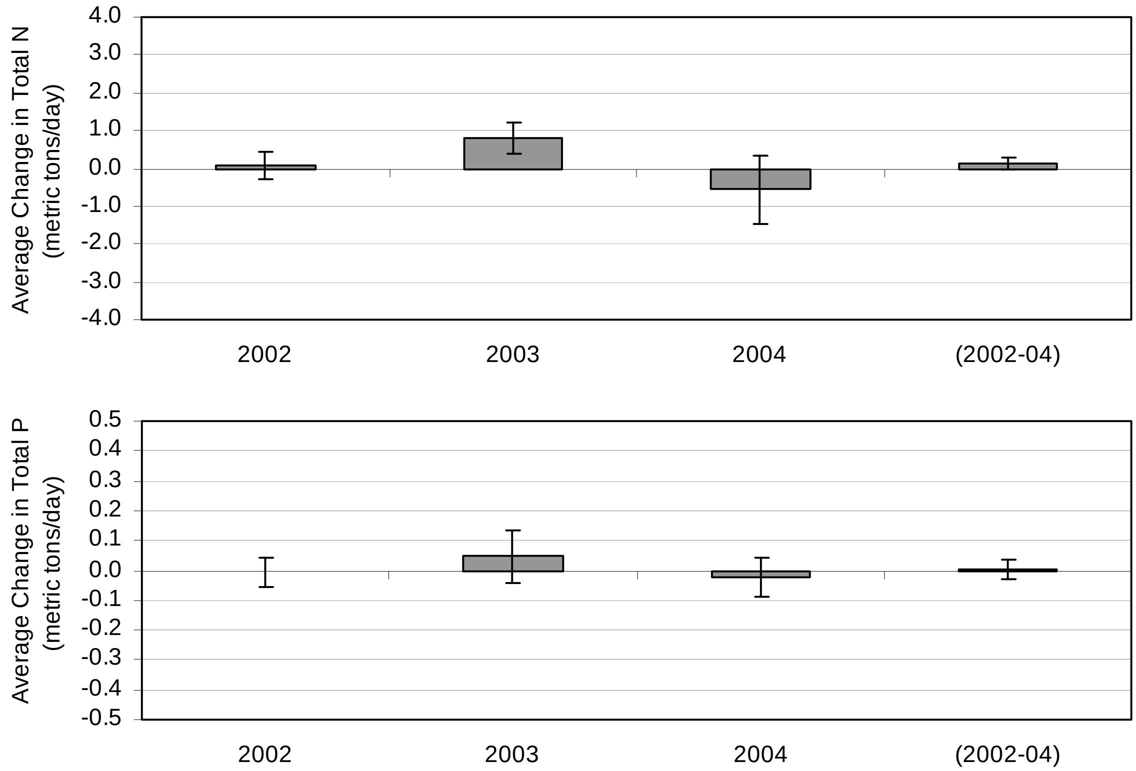


Figure 4.2-13. Annual change in total nitrogen (top plot) and total phosphorous (bottom plot), in metric tons/day, in the inflow versus outflow of J.C. Boyle reservoir, 2002, 2003, 2004, and 2004-2004 (positive represents increase, negative represents decrease). The 90 percent confidence intervals are represented by error bars.

4.2.5.4 Dissolved Gases

Dissolved oxygen concentrations in J.C. Boyle reservoir generally vary from about 5 mg/L to 11 mg/L depending on time of year (see upper right plot in Figure 4.2-12 for example year 2009). Dissolved oxygen concentrations can fall to about 3 mg/L during summer, but are typically 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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). Dissolved oxygen concentrations in water released from the reservoir are often similar to or slightly greater than inflow concentrations (see Figure 4.2-10 for RM 228 [above J.C. Boyle reservoir] compared to site at RM 224 [below J.C. Boyle reservoir]), but there are times 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 (PacifiCorp 2004e, PacifiCorp 2008a).

4.2.5.5 Alkalinity and pH

Alkalinity does not appreciably change between the inflow and outflow of J.C. Boyle reservoir (see Figure 4.2-11 for RM 228 [above J.C. Boyle reservoir] compared to site at RM 224 [below J.C. Boyle reservoir]). pH values are generally equal to or lower below J.C. Boyle dam than upstream of the reservoir (Figure 4.2-11). An exception is that during summer periods, pH is occasionally higher below J.C. Boyle dam than above J.C. Boyle reservoir (PacifiCorp 2004e, PacifiCorp 2008a). 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 (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008a, ODEQ 2010). 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 (PacifiCorp 2006, ODEQ 2010). 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 (Upper Klamath Lake, Keno reservoir). In general, the reservoir is not producing marked reductions or increases in nutrients or organic matter (PacifiCorp 2006, ODEQ 2010).

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. The bypass reach consists of the upper 4 miles of a 20-mile stretch of the Klamath River that is typified by a relatively high-gradient and fast-flowing river channel that lies within a confined canyon running between J.C. Boyle reservoir and Copco reservoir downriver.

4.2.6.1 Hydrology

A minimum instream flow of 100 cfs is released from J.C. Boyle dam to meet instream flow and fish ladder requirements. Large inflows (220 to 250 cfs) enter the bypass reach through a series of springs that are distributed over about the upper 1½ miles of the bypass reach 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 during large spill events, which occur on occasion in the winter and spring when flows in the river exceed about 3,000 cfs (PacifiCorp 2004e).

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 water temperature conditions within this reach down to the J.C. Boyle powerhouse. This is evidenced in Figure 4.2-14 showing examples of water temperature trends from hourly model simulations for example year 2004 for the bypass reach just below J.C. Boyle dam (RM 224) and just below the J.C. Boyle powerhouse (RM 220). 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 water temperature conditions 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 otherwise exceed 25°C. Flows out of the bypass reach range in temperature from less than 10°C in winter to as much as about 18°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 temperatures between the river and the springs (for example, see April-May and mid-September to mid-October periods in Figure 4.2-14).

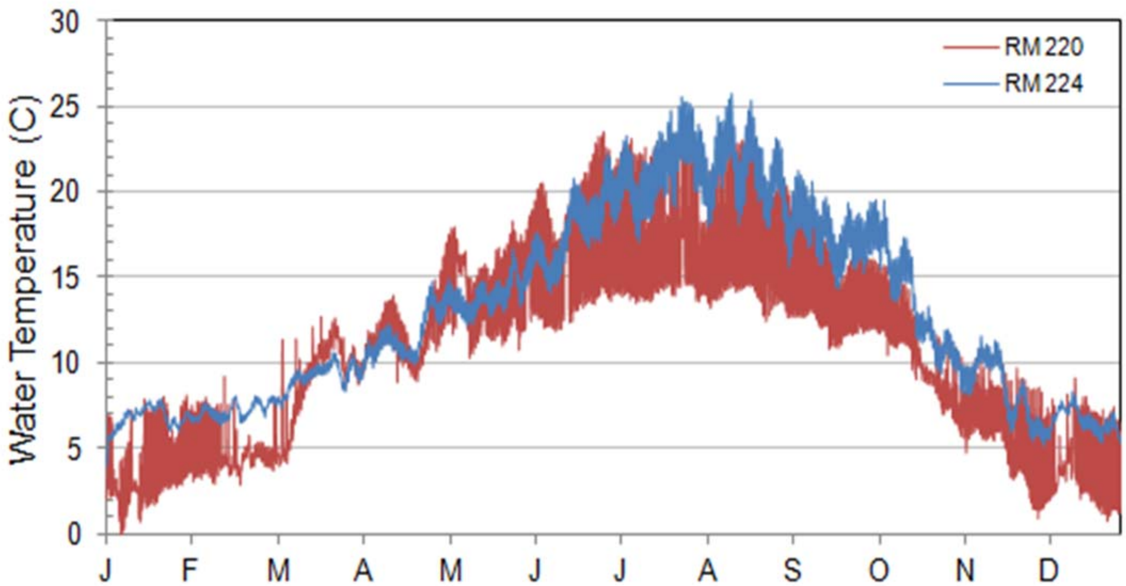


Figure 4.2-14. Water temperatures from hourly model simulations for example year 2004 for the Klamath River in the bypass reach just below J.C. Boyle dam (RM 224) and below the J.C. Boyle powerhouse (RM 220).

PacifiCorp has noted 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 a balance of preferred water temperature conditions and available physical habitat for redband/rainbow trout (*Oncorhynchus mykiss*) in the reach (PacifiCorp 2004b, 2004e, 2005a, 2005e, 2008). Modeling by PacifiCorp indicates that increasing instream flows would adversely impact the beneficial cooling effects of the 250 cfs of springs that discharge into the reach (PacifiCorp 2004b, 2004e, 2005a, 2005e, 2008). The modeling demonstrates that as bypass release flows are incrementally increased, water temperatures in the bypass reach are incrementally warmed to unsuitable levels (> 21°C), particularly if instream flow releases are 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, if the instream flow release to the bypass reach were incrementally increased, water temperatures in the bypass reach would be incrementally warmed as the cooling benefits of the significant groundwater accretions in this reach were progressively diminished. Bartholow and Heasley's (2005) estimates suggest that a release from J.C. Boyle dam of 100 cfs retains high quality water temperature conditions in 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 [do] 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 concentrations are generally reduced by this ratio (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). 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. Contribution of nutrients from the springs may also be a factor. Estimating concentrations of the spring inflow with a simple mass balance using available field data suggests that the background nutrient concentrations of the springs are approximately 0.15 mg/L of both 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 (PacifiCorp 2004e, Raymond 2008b, Raymond 2009b, Raymond 2010b). 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).

4.2.6.4 Dissolved Gases

Field monitoring in this reach indicates that the relatively steep, turbulent nature of the bypass reach typically results in maintaining the waters in the bypass reach at or near saturation through natural mechanical reaeration (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). Dissolved oxygen conditions of the spring inputs are assumed to be at or near saturation, although 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. There is a modest diurnal variation in observed dissolved oxygen concentrations above the powerhouse in the summer (PacifiCorp 2004e, PacifiCorp 2008a). 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

Alkalinity concentrations are generally lower at the lower end of the bypass reach than at the upper end just below J.C. Boyle dam (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). This suggest that the spring inflows apparently have a lower alkalinity (i.e., are more weakly buffered) than the river water—at least seasonally. Values of pH are roughly similar at the top and bottom of the bypass reach, although 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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a).

4.2.6.6 Summary and Relationship to System Water Quality

The residence time of waters moving through the bypass reach is short (on the order of hours), and flows in the reach are mostly 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. The consistent reduction in total nitrogen, total phosphorous, and organic carbon data suggests that the principal "process" in this reach is dilution (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). The physical constraints imposed by the relatively high gradient and turbulent nature of the bypass reach appear to limit the ability to support a large standing crop of attached algae. Other processes in this reach include mechanical 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 as a result of 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). The physical character of the peaking reach is generally similar to the upstream bypass reach, as the peaking reach also is a relatively high-gradient and fast-flowing river channel within a confined canyon setting. Noteworthy features of the peaking reach at its head end include the powerhouse tailrace discharge combined with the influence of the bypass reach flows. There are some small streams that enter 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 in which powerhouse releases (equivalent to J.C. Boyle reservoir release water quality) dominate the downstream water quality.

4.2.7.1 Hydrology

The J.C. Boyle powerhouse typically is operated as a power peaking facility, especially when river flows are less than the approximately 3,000-cfs maximum turbine hydraulic capacity (see Section 3.1.3.2). During the summer months, peaking typically occurs on weekdays in the afternoons and early evenings. 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 spring water flowing in from the upstream bypass reach. This low flow condition generally occurs during the late evening to the mid-to late-morning period, as well as other periods when the powerhouse is off-line.

The mean annual flow for the Klamath River below the J.C. Boyle powerhouse (USGS 11510700) is 1.247 MAF (million acre-feet) per year, which is approximately 120 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. Inflow temperatures from the bypass reach are represented by the thermograph data for the lower end of the bypass reach (RM 220) in Figure 4.2-14. In addition, water temperatures released from the powerhouse are essentially represented by the thermograph data for the upper end of the bypass reach (RM 224) in Figure 4.2-14, since the RM 224 water temperature also represent water temperature in the flows diverted into the power conduit at J.C. Boyle dam.

The inflow temperatures from the bypass reach and the powerhouse are generally well mixed within a short distance downstream due to the configuration of the powerhouse discharge and downstream river reach, and the relatively large flow rates associated with powerhouse discharges. During the warmer periods of the year, the river heats in the downstream direction, with a diurnal range of over 5°C at times. This is evidenced in Figure 4.2-15, which shows examples of water temperature trends from hourly model simulations for example year 2004 for the peaking reach just below J.C. Boyle powerhouse (RM 220), at Stateline (RM 209), and above Copco reservoir (RM 204). During summer periods, the combined flow at the head end of the peaking reach is often less than equilibrium water temperature conditions (due to the substantial cool water contribution from the springs in the bypass reach), and the water subsequently warms en route to Copco reservoir. During winter months, the combined flow below the powerhouse is often above equilibrium temperature due to bypass reach contributions, and the water may cool in the downstream direction (for example, see the mid-November to December period in Figure 4.2-15).

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

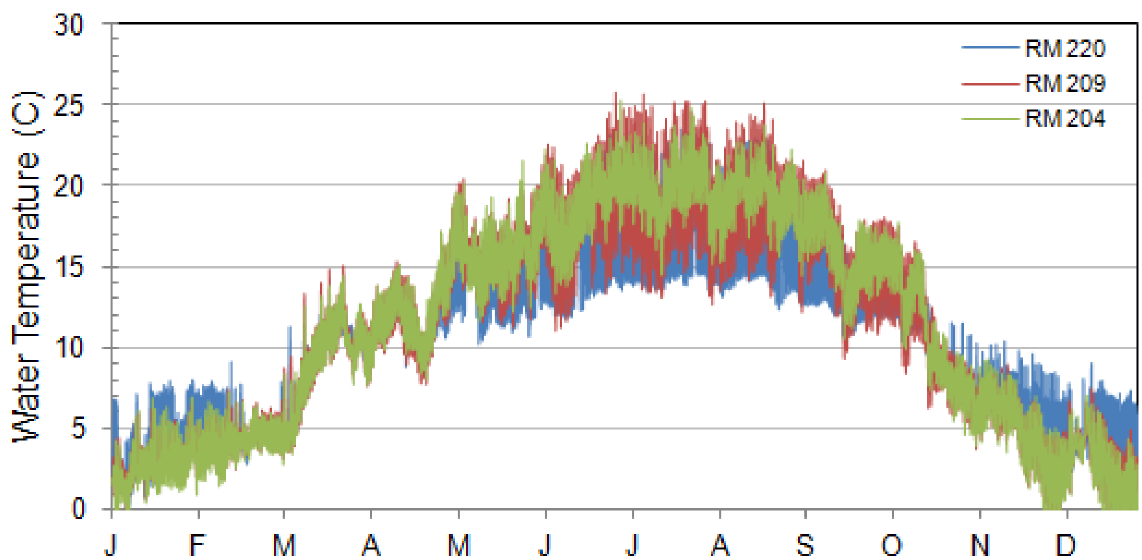


Figure 4.2-15. Water temperatures from hourly model simulations for example year 2004 for the Klamath River in the peaking reach just below J.C. Boyle powerhouse (RM 220), at Stateline (RM 209), and above Copco reservoir (RM 204).

4.2.7.3 Nutrients and Algal Production

Total phosphorous and total nitrogen are generally lower at the bottom of the J.C. Boyle peaking reach than at the top (see Figure 4.2-1 for monitoring sites at RM 219.5 [below the J.C. Boyle powerhouse] and RM 206.4 [above Copco reservoir near Shovel Creek]). In general these apparent reductions are relatively modest and may reflect reduction via dilution (e.g., from tributary streams) and uptake from attached algae (periphyton) in the 16-mile reach (rather than phytoplankton, which generally perform poorly in dynamic river conditions). 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 (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008).

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 typically increases in the J.C. Boyle peaking reach as waters flow from the upper to lower ends of the reach (for example, see Figure 4.2-10 for sites below J.C. Boyle powerhouse [RM 220] and above Copco reservoir near Shovel Creek [RM 206]). Dissolved oxygen concentrations generally range between about 7 mg/L to 10 mg/L at the upper end of the peaking reach, and between about 9 mg/L to 11 mg/L in the lower end of the reach. The relatively steep, turbulent nature of the peaking reach is expected to drive the waters toward saturation through natural mechanical reaeration (PacifiCorp 2004e). Mechanical reaeration throughout much of the reach results in dissolved oxygen conditions at or near saturation (Chapra 1997, Thomann and Mueller 1987). However, primary production from attached algae (periphyton) may also play 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.

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 appreciably within the peaking reach (see Figure 4.2-11 for sites below J.C. Boyle powerhouse [RM 220] and above Copco reservoir near Shovel Creek [RM 206]). The alkalinity of the waters in the reach remain well under 100 mg/L, indicating the Klamath River system remains weakly buffered in this reach (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). 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 (Figure 4.2-11). 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 relatively dynamic reach from a water quality perspective, due to the combination of: (1) enriched waters entering from upriver; (2) variable powerhouse discharges; (3) spring contributions from the bypass reach; and (4) the relatively high-gradient turbulent nature of the reach. Inflows from the bypass reach provide dilution and reduce overall nutrient concentrations accordingly. Spring contributions from the bypass reach lead to water temperatures below equilibrium in the upper reaches, which subsequently heat as water traverses the reach. Field data suggest that the turbulent nature of the river is this reach acts to maintain dissolved oxygen near saturation as waters flow downstream.

Nutrients are modestly but consistently reduced. The reductions in nutrient values are close to the dilution ratio of the springs to total mainstem flows during the summer period, but are likely also affected by uptake from attached algae (periphyton) production and other factors.

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 (see Table 3.1-1).

4.2.8.1 Hydrology

Copco No. 1 and No. 2 typically operate in a coordinated fashion. 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 often mimics flow through the upstream J.C. Boyle development on a daily average basis (with a time lag). However, the plants are independent and can, and do, operate separately to accommodate separate plant maintenance schedules or for other reasons.

Copco reservoir's hydraulic residence times range from about one week under winter high flow events to about 3 weeks under typical summer conditions (see Table 3.1-1). 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, PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). Because of these density driven flow conditions, the surface waters may have a residence time that is longer than 3 weeks. These conditions play an important role in water quality response of the reservoir to upstream flow fluctuations.

4.2.8.2 Water Temperature

The onset of seasonal stratification in Copco reservoir typically occurs in mid to late March, and the breakdown of stratification in October (see upper left plot in Figure 4.2-16 for example year 2009). 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 (Figure 4.2-16). This cool pool of water is relatively small (approximate annual minimum is less than 2,000 AF).

Release waters from Copco reservoir (at Copco No. 1 dam) are sometimes warmer and sometimes cooler than the Klamath River temperatures upstream of the reservoir. The increased thermal mass of the reservoir's volume causes a slight lag between the seasonal onset of cooling and heating, resulting in outflow temperatures at Copco No. 1 dam that are slightly cooler in spring and warmer in later summer and fall. This is evidenced in Figure 4.2-17 showing examples of water temperature trends from hourly model simulations for example year 2004 for the Klamath River just above Copco reservoir (RM 204) and downstream of Copco No. 1 dam (RM 198). The increased thermal mass of the reservoir's volume also causes a lower annual maximum water temperature (e.g., 22°C versus 25°C in Figure 4.2-16) and much narrower (i.e., a reduced range of) diel water temperatures fluctuations in the reservoir's outflow compared to inflow (Figure 4.2-17).

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

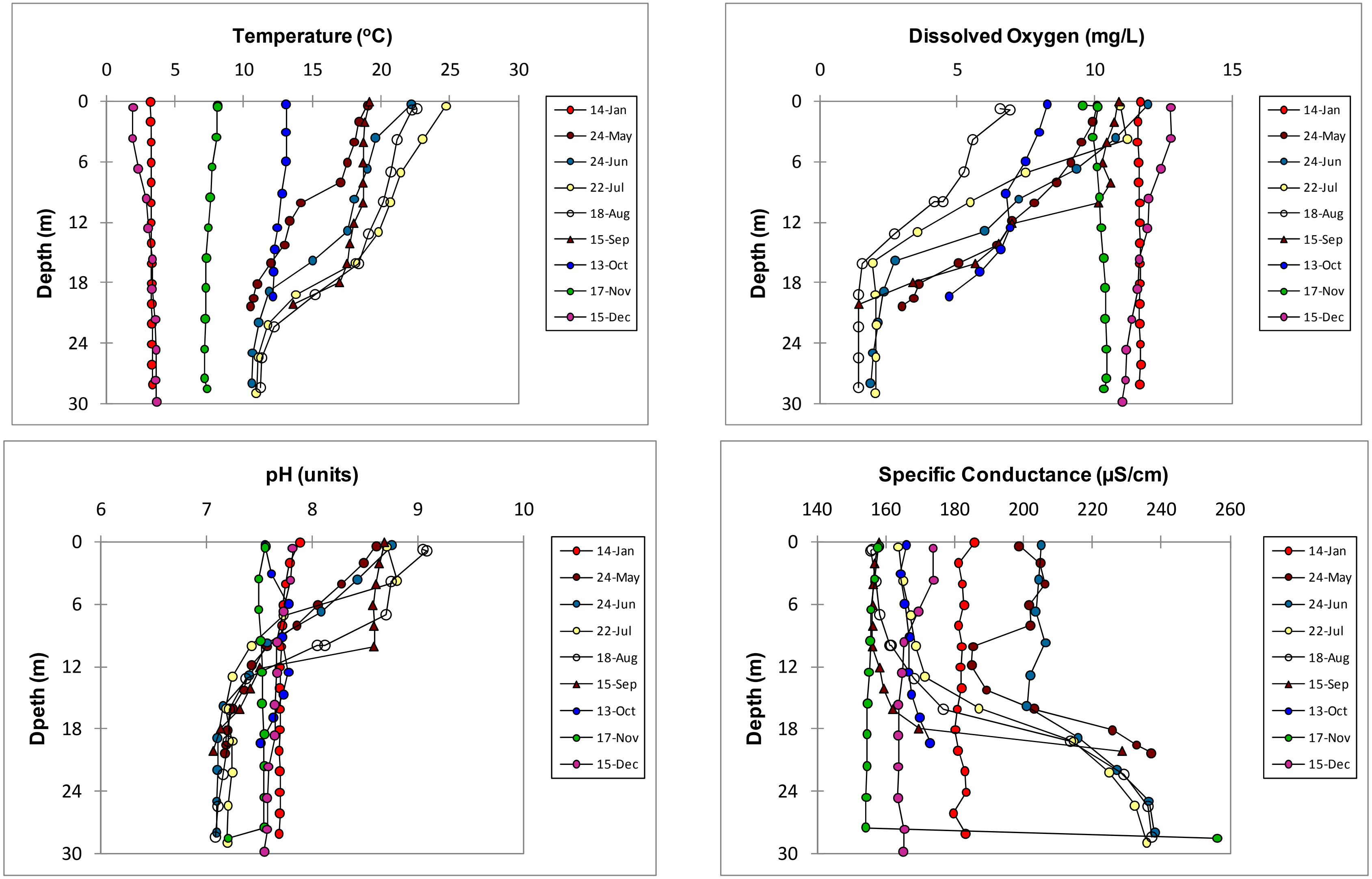


Figure 4.2-16. Vertical profile measurements of water temperature, dissolved oxygen, pH, and specific conductance in Copco reservoir in 2009. See Raymond (2010) for more details.

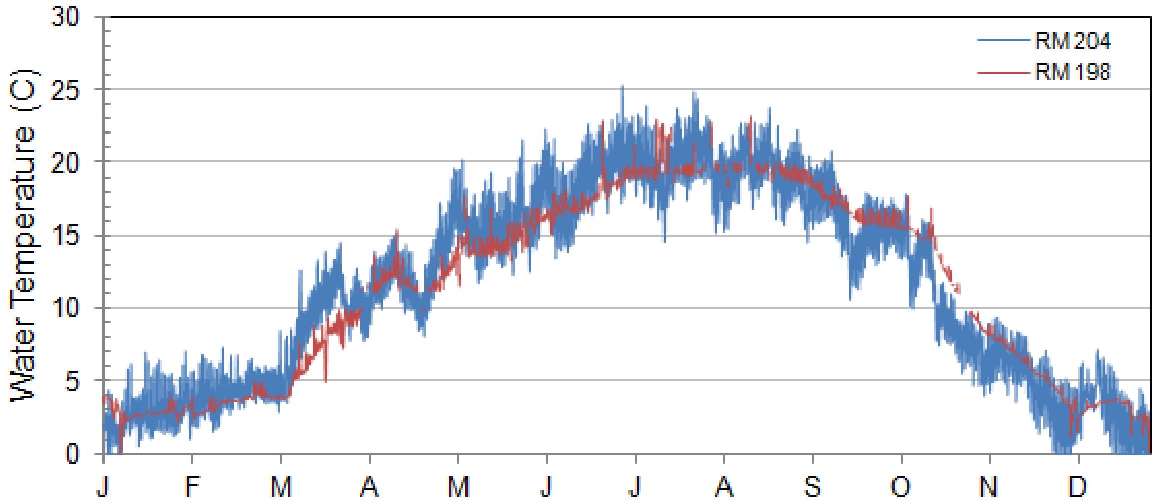


Figure 4.2-17. Water temperatures from hourly model simulations for example year 2004 for the Klamath River in the peaking reach above Copco reservoir (RM 204) and below Copco No.1 dam (RM 198).

4.2.8.3 Nutrients and Algal Production

Copco reservoir water quality responds strongly to variations in the quantity and quality of inflow nutrients from upstream sources, particularly Upper Klamath Lake. Transit time of nutrient-laden water from Upper Klamath Lake at Link River 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, nutrients and organic matter associated with algal blooms from Upper Klamath Lake and Keno reservoir can 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. Copco reservoir water quality then responds as a result of the subsequent decay of organic forms of nutrients to inorganic forms, uptake of inorganic nutrients by algae, and other processes (e.g., mixing and settling) in the reservoir (Horne and Goldman 1994, Kalff 2002, Wetzel 2001).

Copco reservoir acts as an annual net sink for portions of the large inflow loads of both total phosphorous and total nitrogen (PacifiCorp 2006, Asarian et al. 2009). Reservoirs can act as traps, reducing organic matter, nutrient, and particulate matter (Thornton et al. 1990, Ward and Stanford 1983). For example, over a two-year study period (i.e., April 2005-April 2007), Asarian et al. (2009) determined that Copco reservoir retained about 35 metric tons of total phosphorus (equivalent to about 7 percent of the inflow load) and 374 metric tons of total nitrogen (also about 7 percent of the inflow load).

The effect of upstream nutrient loads 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, although the reservoir retains nutrients over the long term (e.g., months, years) as described above. For example, following a bloom event in the upper system (Upper Klamath Lake, Keno), poor water quality conditions abate, and inflowing waters to Copco begin to improve. Simultaneously, however, Copco reservoir outflow water quality 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). Diatoms (Bacillariophyta) typically dominate in spring when water temperatures are cooler (Raymond 2008b, Raymond 2009b, Raymond 2010b). Dinoflagellates (Dinophyta) may reach appreciable numbers in May and green algae

(Chlorophyta) increase to a peak in June or July. Cyanobacteria or blue-green algae (Cyanophyta) start increasing to large numbers in July and reach maximums in August and September.

The trends in total phytoplankton biovolume and chlorophyll-a concentrations in Copco reservoir are consistent with the algal dominance and succession pattern as described above (PacifiCorp 2004e, PacifiCorp 2008b, Raymond 2008b, Raymond 2009b, Raymond 2010b). 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 mostly 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.

Aphanizomenon is usually the dominant bloom-forming cyanobacteria species, although blooms of *Microcystis* have been observed since 2005, particularly in late summer (Prendergast and Foster 2010). The California Department of Public Health (CDPH 2013) reports that *Microcystis* blooms are occurring with greater frequency in California than in the past. This greater frequency is in line with the recent reports that nutrient over-enrichment (eutrophication) and climate-change effects have led to a rise in toxin-producing cyanobacterial blooms in freshwater systems worldwide (Paerl and Otten 2013). In addition to the Klamath River system, *Microcystis* and microcystin are reported to occur throughout California, including (but not limited to) the San Francisco Bay up into the Sacramento and San Joaquin Rivers, Eel River (Humboldt County), Van Duzen River (Humboldt County), Clear Lake (Lake County), Lake Isabella (Kern County), Crowley Lake (Mono County), Lake Elsinore (Riverside County), Pinto Lake (Santa Cruz County), the Salton Sea (Imperial County), Lake Mathews (Riverside County), Lake Skinner (Riverside County), Diamond Valley Lake (Riverside County), and Lake Perris (Riverside County) (CDPH 2013, Butler et al. 2009).

Microcystis is of particular interest because of its potential to produce toxins (e.g., microcystin) that can present a public health risk at high concentration (Raymond 2008b, Raymond 2009b, Raymond 2010b). Certain conditions favor *Microcystis* over *Aphanizomenon*. For example, an abundance of ammonia gives a competitive edge to *Microcystis*. Sustained *Microcystis* blooms in Copco reservoir are consistent with the potentially elevated levels of inorganic nitrogen (e.g., ammonia, nitrate) and organic matter in influent waters. Evidence of this can be seen in Figure 4.2-18 that compares plots of *Microcystis* biovolume collected in Copco and Iron Gate reservoirs during 2001 through 2009 (as reported by Raymond [2010]) with concentrations of total phosphorus and total nitrogen in the outflow from Upper Klamath Lake (as reported by Walker et al. [2012]). Increases in *Microcystis* biovolumes in Copco reservoir in more recent years (e.g., 2007 to 2009) have occurred coincident with increases in nitrogen in the outflow from Upper Klamath Lake (Figure 4.2-18).

Microcystis aeruginosa can be a concern because it can be found in Copco and Iron Gate reservoirs in numbers that exceed public health guidelines. For example, Figure 4.2-17 (top plot) shows all the instances when *Microcystis* were observed in reservoir samples taken by PacifiCorp from 2001 through 2009 (Raymond 2010). The dashed line at 320,000 μm^3/mL (in the upper plot of Figure 4.2-17) represents the approximate biovolume equal to the SWRCB (2010) guideline value of 40,000 cells/mL[12]. Despite some differences in sampling frequency during those years, it appears that *Microcystis* abundance has increased in recent years as described above.

[12] SWRCB (2010) indicates that Microcystis cell counts of 40,000 cells/mL and 100,000 cells/mL equate to microcystin toxin concentrations of 8 μg/L and 20 μg/L, respectively. The World Health Organization (WHO) has recommended microcystin toxin concentrations of 8 μg/L and 20 μg/L as guidelines for defining safe recreational water environments based on a low, moderate, or high probability of adverse health effects from exposure to concentrations of cyanobacterial cells and microcystin toxins in recreational waters (WHO 2003).

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

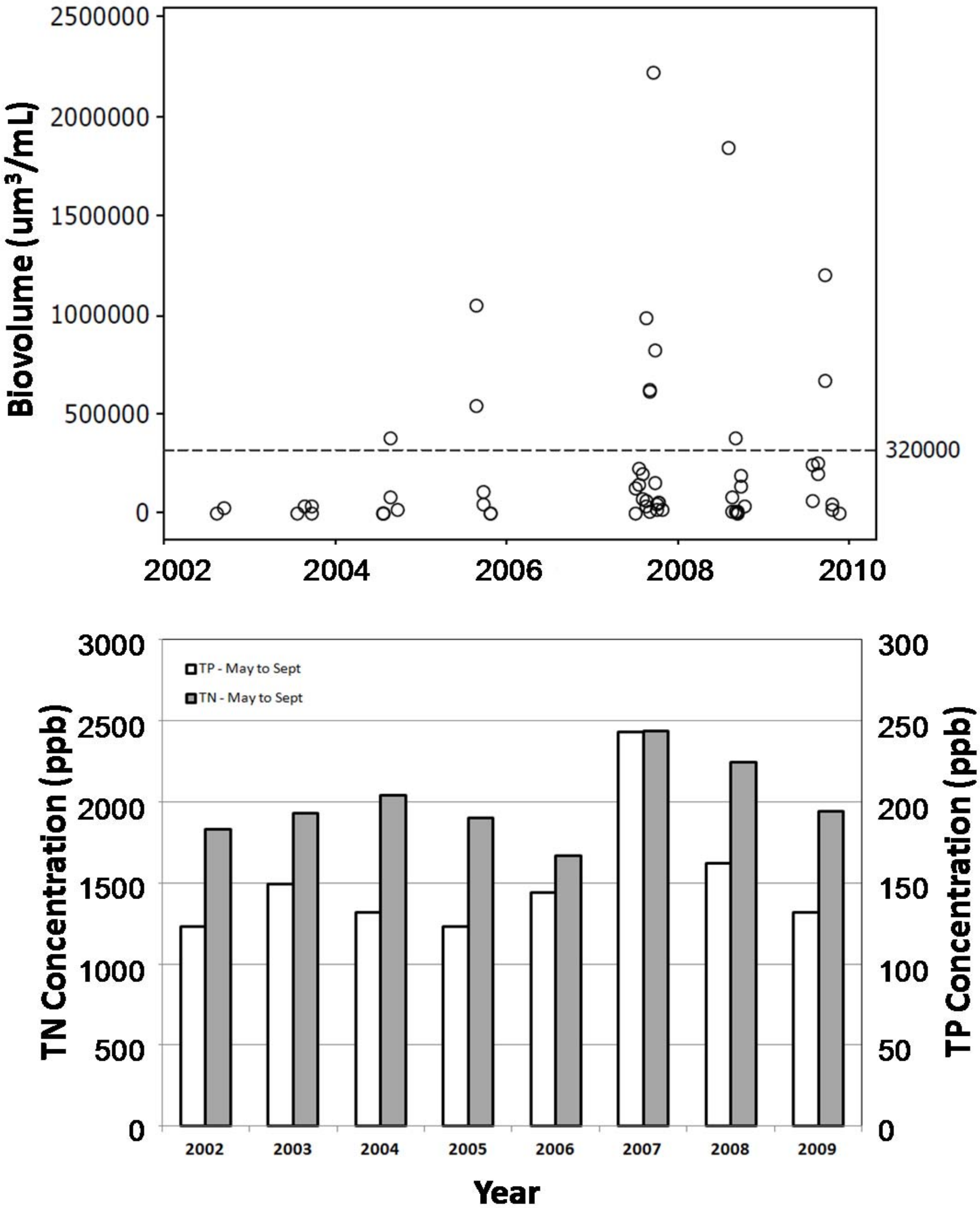


Figure 4.2-18. *Microcystis aeruginosa* biovolume measured in Copco and Iron Gate reservoirs during 2001 through 2009 as reported by Raymond (2010) (upper plot) and flow-weighted mean concentrations of total phosphorus and total nitrogen in the outflow from Upper Klamath Lake as reported by Walker et al. (2012) (lower plot).

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 (see upper right plot in Figure 4.2-16 for example year 2009). Under isothermal conditions in winter and early spring, dissolved oxygen concentrations are generally at or near full saturation at 10 mg/L to 13 mg/L (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a).

Under thermally-stratified conditions in the reservoir during late spring through fall, the reservoir is productive, leading to dissolved oxygen concentrations in surface waters during the growth season that are at or near full saturation at 8 mg/L to 11 mg/L (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). However, during this same period, low dissolved oxygen conditions (hypoxia) occur in the deeper waters of the reservoir (Figure 4.2-16). The lowest dissolved oxygen conditions occur in July when roughly the bottom 60 feet of the reservoir can have dissolved oxygen concentrations near 1.0 mg/L. Dissolved oxygen concentrations in water released from Copco reservoir are typically below saturation from mid-summer through mid-fall, with minimum values in late September to early October reflecting the subsaturated conditions within deeper portions of the reservoir (PacifiCorp 2004e, PacifiCorp 2008b).

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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). 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 Upper Klamath Lake and the Klamath River. When anoxia is present in the deeper portions of the reservoir, it is not uncommon for pH values to fall below 6, even during summer periods (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a).

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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). 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. This reduction in total suspended solids is expected given the opportunity for settling of particulate matter as a result of the relatively long residence time of the reservoir (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a).

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 Upper Klamath Lake. As such, it receives and processes the water quality that is ultimately borne out of Upper Klamath Lake and any agricultural and municipal/industrial return flows. The result of these substantial upstream loads causes eutrophic conditions in Copco reservoir (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b, NCRWQCB 2010).

Copco reservoir is generally productive during summer months, and can produce blooms of cyanobacteria (e.g., *Aphanizomenon*, *Microcystis*), particularly if the influx of nutrients to the reservoir increases in response to the large upstream loads of organic matter and nutrients. In general, 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 the processing of organic matter and nutrients and the production of algae (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b). 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 Reclamation's Rogue River Basin Project. 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 (see Table 3.1-1).

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 with regard to thermal stratification, dissolved oxygen conditions, and water quality responses. However, as discussed in the following sections, the fact that Iron Gate reservoir receives discharge from an upstream reservoir versus a river reach results in some characteristic differences between the processes within Iron Gate reservoir and Copco reservoir.

4.2.9.1 Hydrology

The Iron Gate development was constructed and is operated to serve as the Project's regulating facility and generation schedules currently reflect instream flow requirements and ramp rates as directed by Reclamation (see Section 3.1.3.3.). Exceptions may occur seasonally when high river inflows result in spills. Flow releases from the Iron Gate powerhouse can be as much as 1,735 cfs. When flows are higher, or when higher flows are needed to meet downstream flow requirements, additional water is passed over Iron Gate dam's ungated spillway.

Iron Gate reservoir's hydraulic residence times range from a week or so under winter high flow events to approximately 3 to 5 weeks under typical summer conditions (see Table 3.1-1). 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, Ford 1990, PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). Because of these density-driven flow conditions, the surface waters may have a residence time that is longer than 3 to 5 weeks. These conditions play an important role in the water quality response of the reservoir to upstream inorganic and organic nutrient 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 (PacifiCorp 2004e, PacifiCorp 2008b).

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 occurs in November (see upper left plot in Figure 4.2-19 for example year 2009). Iron Gate reservoir thermal profiles indicate a strong seasonal thermal stratification. Copco reservoir provides fairly constant temperature inflows to Iron Gate reservoir that follow a general seasonal response, but with little or no short term (e.g., daily) temperature variation (Figure 4.2-20). 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 fall turnover (destratification) is in response to fairly stable inflow temperatures from Copco reservoir. Thus, the effect that variable temperature inflows might otherwise have on destratification (Fischer 1979) is reduced, and the role of convective cooling within the reservoir plays a more prominent role in fall destratification of Iron Gate reservoir (PacifiCorp 2004e, PacifiCorp 2008b).

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 (see upper left plot in Figure 4.2-19). The bottom waters of Iron Gate reservoir are appreciably cooler than Copco reservoir owing to the larger storage volume and greater depth of Iron Gate and the generally stable (short-term) inflow temperatures from Copco No. 2 powerhouse releases to Iron Gate reservoir. These conditions minimize mixing into the deeper portions of Iron Gate reservoir and create a fairly isolated colder-water hypolimnion (estimated at approximately 5,000 AF in volume). The Iron Gate fish hatchery draws on this hypolimnetic 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 through summer, the reservoir releases are generally below equilibrium water temperature conditions. In fact, the annual maximum water temperature (during mid-summer) in the Klamath River just below the release from Iron Gate dam is typically less than 23°C (Figure 4.2-20), which makes this location among the coolest mid-summer locations in the Klamath River system. In the late fall and winter, reservoir release temperatures tend to be above equilibrium water temperature conditions because of the insulating effects of the large mass of the reservoir’s volume (compared to the river).

Throughout the year, the diurnal range of release temperatures from Iron Gate reservoir is moderated by the mass (volume) of the reservoir. When the reservoir is thermally stratified (about March through October), water 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 (Figure 4.2-20). Owing to the mass of Iron Gate reservoir, release waters from Iron Gate dam are mostly warmer than the inflows from the Copco No. 2 powerhouse in the late fall and winter.

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

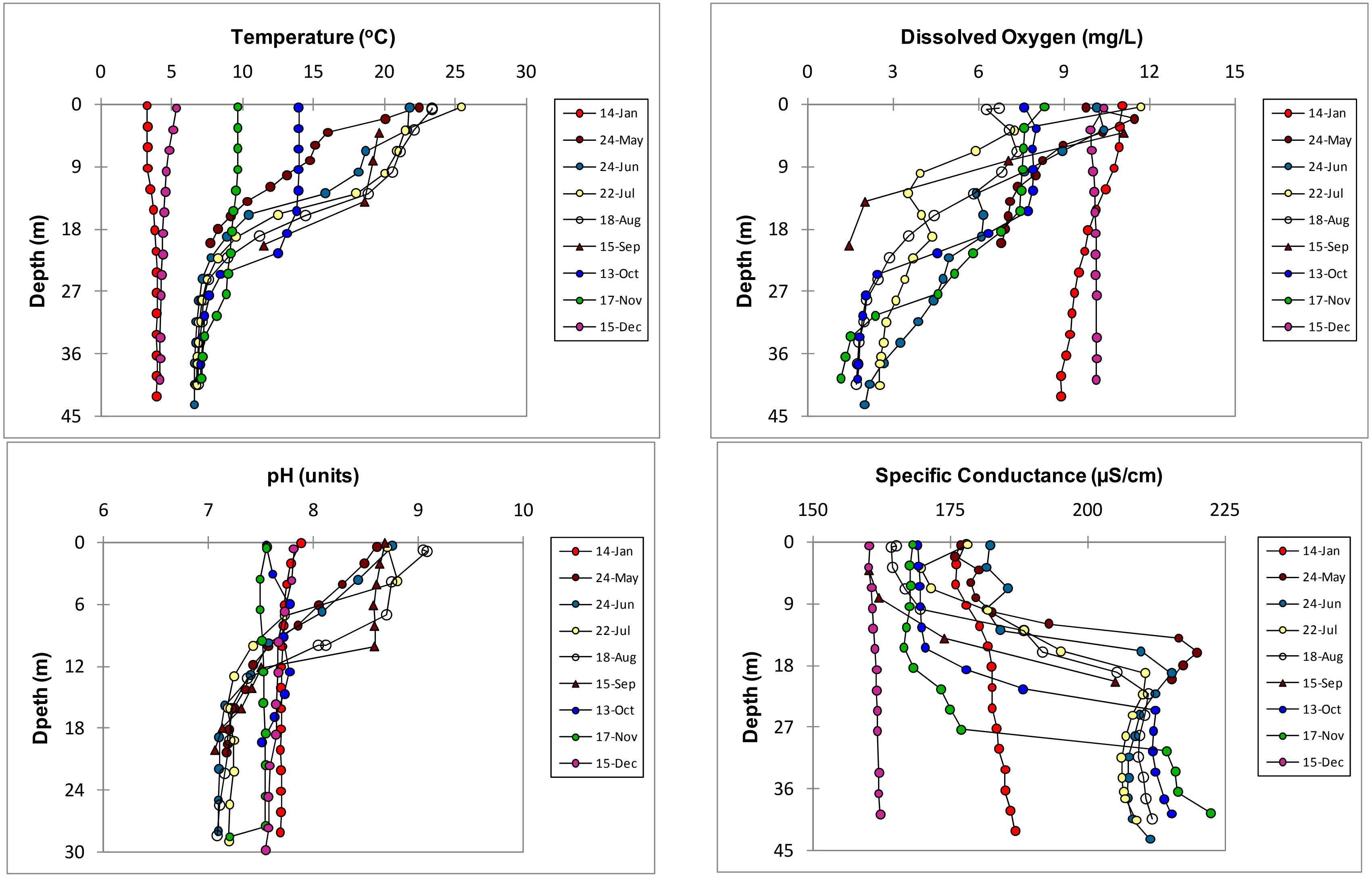


Figure 4.2-19. Vertical profile measurements of water temperature, dissolved oxygen, pH, and specific conductance in Iron Gate reservoir in 2009. See Raymond (2010) for more details.

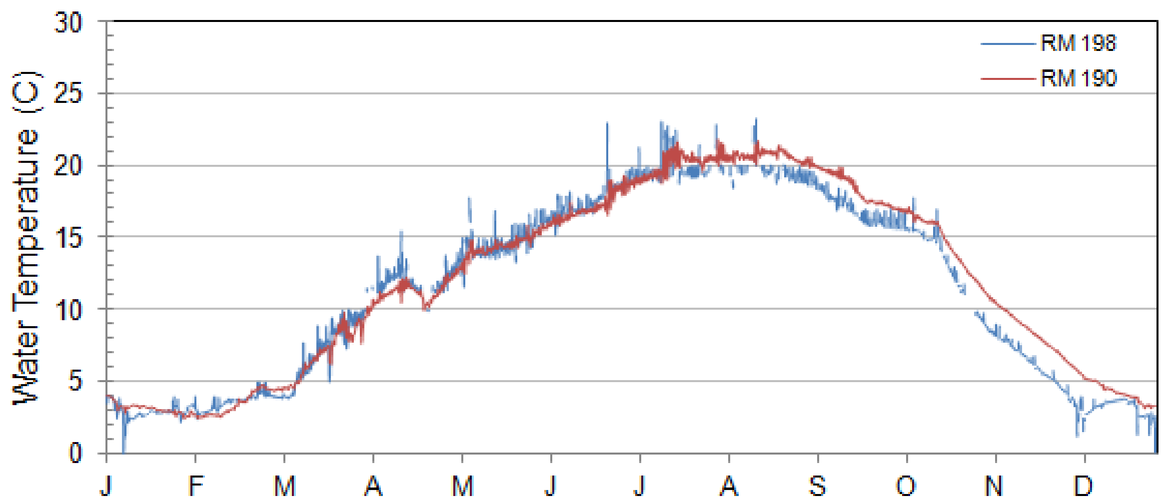


Figure 4.2-20. Water temperatures from hourly model simulations for example year 2004 for the Klamath River below Copco No.1 dam (RM 198) and below Iron Gate reservoir (RM 190).

4.2.9.3 Nutrients and Algal Production

Conditions in Iron Gate reservoir are eutrophic due to nutrient inputs (organic and inorganic) from upstream sources, notably Upper Klamath Lake. Tributary inputs directly to Iron Gate reservoir are insignificant in comparison to Klamath River inflows. 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 Iron Gate reservoir from these upstream sources can affect water quality conditions during summer periods.

Iron Gate reservoir acts as an annual net sink for portion of the large inflow loads of total phosphorus and total nitrogen (PacifiCorp 2006, Asarian et al. 2009). Reservoirs can act as traps, reducing organic matter, nutrient, and particulate matter in the downstream river system (Thornton et al. 1990, Ward and Stanford 1983). For example, over a two-year study period (i.e., April 2005-April 2007), Asarian et al. (2009) determined that Iron Gate reservoir retained about 23 metric tons of total phosphorus (equivalent to about 4 percent of the inflow load) and 304 metric tons of total nitrogen (about 6 percent of the inflow load). For Iron Gate and Copco reservoirs in combination, Asarian et al. (2009) determined that the reservoirs together retained about 58 metric tons of total phosphorus (about 11 percent of the inflow load) and 678 metric tons of total nitrogen (about 12 percent of the inflow load).

The effect of upstream nutrient loads 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, although the reservoir retains nutrients over the long term (e.g., month, years) as described above. The annual contribution to the reservoir's nutrient loading from internal reservoir nutrient cycling (e.g., nutrient release from sediments under anoxic conditions) is probably not significant, due to: (1) the comparatively large hydraulic and nutrient loads from the inflowing Klamath River; (2) the complete replacement of reservoir volume during winter periods; and (3) the reservoir's persistent stratification during the algae growth season.

Algal species in mainstem reservoirs like Iron Gate reservoir show a general succession typical of temperate regions (Kalff 2002, Wetzel 2001, Horn and Goldman 1994), similar to that described for Copco reservoir (in section 4.2.8 above). Diatoms typically dominate in the spring when water temperatures are cooler (Raymond 2008b, Raymond 2009b, Raymond 2010b). Dinoflagellates may reach appreciable numbers in May, and green algae increase to a peak in June or July. Cyanobacteria (blue-green algae) increase to large numbers in July and typically reach maximum levels in August and September.

The trends in total phytoplankton biovolume and chlorophyll-a concentrations in Iron Gate reservoir are consistent with the algal dominance and succession pattern as described above (PacifiCorp 2004e, PacifiCorp 2008b, Raymond 2008b, Raymond 2009b, Raymond 2010b). 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 fairly 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.

Aphanizomenon flos-aquae and *Microcystis aeruginosa* are the two dominant cyanobacteria in Iron Gate reservoir, as they are in Copco reservoir (as described in section 4.2.8 above). In Iron Gate reservoir, *Aphanizomenon* is typically more abundant than *Microcystis*, and the respective numbers of both *Aphanizomenon* and *Microcystis* have been relatively uniform both within years and between years (Raymond 2008b, Raymond 2009b, Raymond 2010b). Notable exceptions were in 2005 when *Microcystis* was more highly variable, and in 2002 and 2007 when *Aphanizomenon* numbers were both unusually high and unusually variable (Raymond 2010b). The average biovolume of both *Aphanizomenon* and *Microcystis* also is less variable in Iron Gate reservoir than in Copco reservoir. These differences between Iron Gate and Copco reservoirs are not fully understood. Possible explanations may include: (1) the several-week lag time of nutrients from upstream sources (e.g., Upper Klamath Lake), first through Copco reservoir, and then into Iron Gate reservoir; (2) the further processing of nutrients from organic to inorganic forms as waters move down through the successive reservoirs; and (3) local reservoir conditions (meteorology, mixing, thermal structure, etc.).

As in Copco reservoir, *Microcystis* can be a concern in Iron Gate reservoir due to levels that can exceed public health guidelines. For example, Figure 4.2-18 (top plot) shows all the instances when *Microcystis* were observed in Iron Gate and Copco reservoir samples taken by PacifiCorp from 2001 through 2009 (Raymond 2010b). The dashed line at 320,000 μm^3/mL (in the upper plot of Figure 4.2-18) represents the approximate biovolume equal to the SWRCB (2010) guideline value of 40,000 cells/mL. Despite some differences in sampling frequency during those years, it appears that *Microcystis* abundance has increased in recent years as described in section 4.2.8.3 above.

Additional information on nutrients and algal 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 (see upper right plot in Figure 4.2-19 for example year 2009). Under isothermal conditions in winter and early spring, dissolved oxygen concentrations are generally at or near full saturation at 9 to 12 mg/L (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). Under stratified conditions in the reservoir during later spring through fall, the reservoir is productive, leading to dissolved oxygen concentrations in surface waters during the growth season that are at or near full saturation at 7 to 9 mg/L (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). However, during this same period (growth season), low dissolved oxygen conditions (hypoxia) occur in the deeper waters of the reservoir (Figure 4.2-19). The lowest (anoxic) conditions occurs in September in the bottom 100 feet of the reservoir waters where dissolved oxygen only reaches maximum concentrations of 2.0 mg/L or less.

Dissolved oxygen levels in water released from Iron Gate reservoir are at or near full (100 percent) saturation at concentrations of 8 mg/L to 10 mg/L during winter, spring, and early summer (see Figure 4.2-21 for example year 2012). From mid-summer through mid-fall, the dissolved oxygen levels in the reservoir releases are typically more variable, ranging both above and below saturation, with minimum values in late September to early October (Figure 4.2-21). The more variable and lower dissolved oxygen conditions in the August-October period reflect: (1) the production and respiration effects from algae blooms at this time; and (2) the increase in subsaturated conditions that occur in the hypolimnion of the reservoir during this time.

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

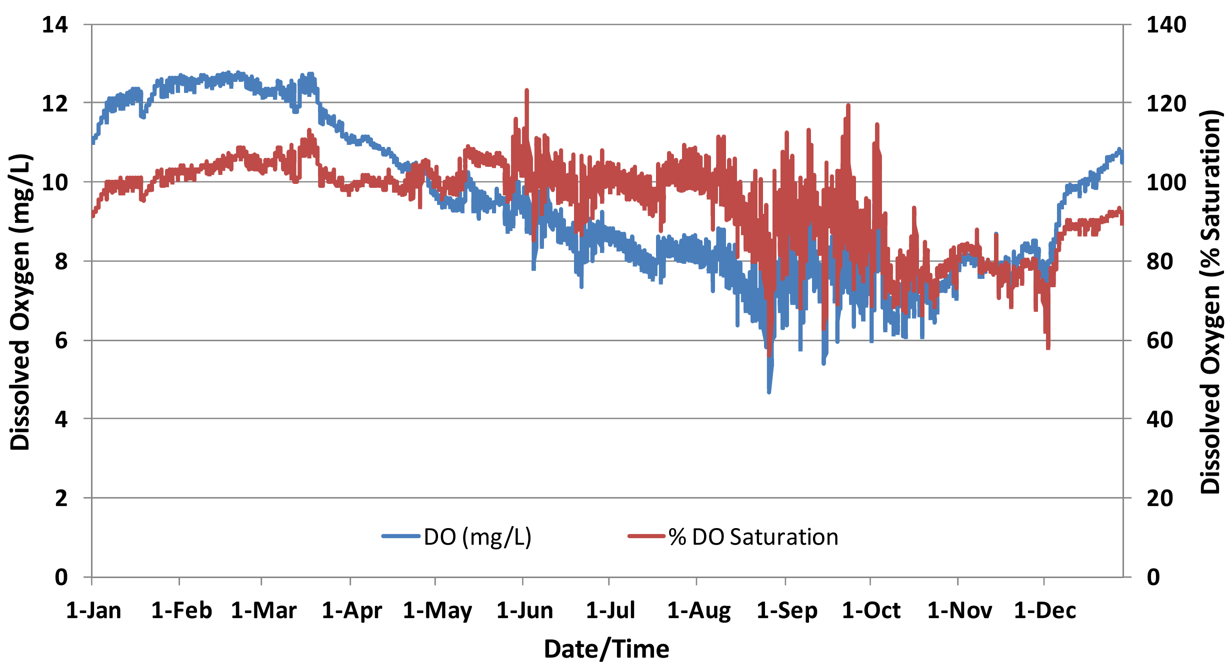


Figure 4.2-21. Dissolved oxygen (in mg/L and % saturation) measured during 2012 by a continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). 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 Upper Klamath Lake and the Klamath River. When anoxia during summer period is present in the deeper portions of Iron Gate reservoir, it is not uncommon for pH values to fall to 6 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a).

Values of pH below Iron Gate dam typically range from about 7.5 to 8 during winter and spring. During summer and fall, pH values below Iron Gate dam are more variable and can reach higher levels near 9 due to the high primary production in the reservoir during this time (Figure 4.2-22).

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 (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). The seasonal 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.

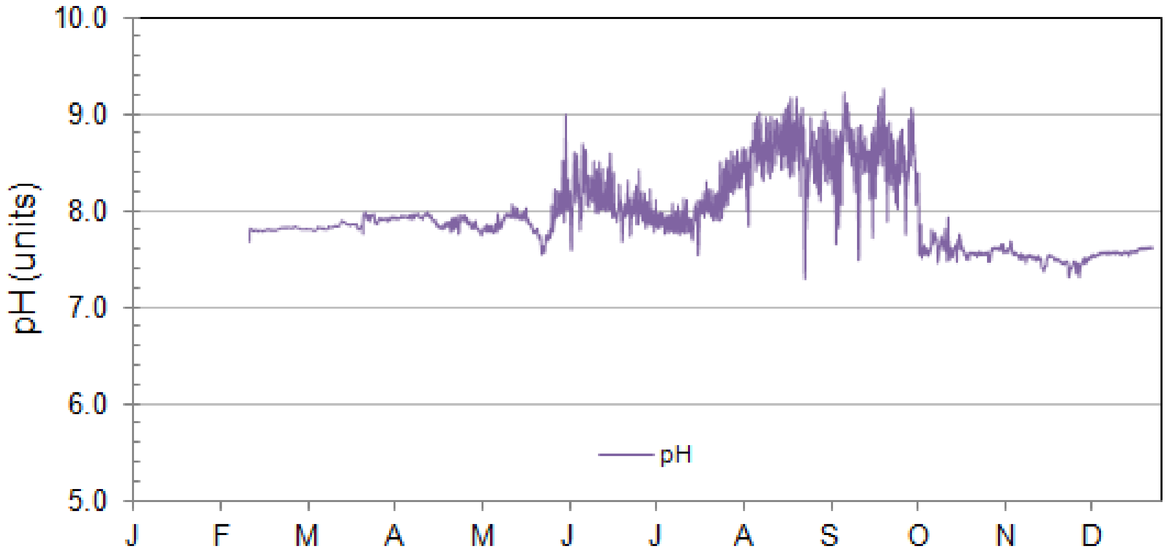


Figure 4.2-22. Values of pH (in units) measured during 2012 by a continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

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. This reduction in total suspended solids is expected given the opportunity for settling of particulate matter as a result of the relatively long residence time of the reservoir (PacifiCorp 2004e, Raymond 2008a, Raymond 2009a, Raymond 2010a). BOD is also generally equal to or lower below the dam than the upstream concentrations (PacifiCorp 2004e, PacifiCorp 2008b). Total organic carbon also is generally lower below Iron Gate dam than the inflows to Copco reservoir or the inflows to Iron Gate reservoir below Copco No. 2 powerhouse (PacifiCorp 2004e, PacifiCorp 2008b).

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 Upper Klamath Lake. Iron Gate reservoir receives large hydraulic and nutrient loads from the inflowing Klamath River. The result of these substantial upstream loads cause eutrophic conditions in Iron Gate reservoir (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b, NCRWQCB 2010).

Iron Gate reservoir is generally productive during summer months, and can produce blooms of algae if the influx of nutrients to the reservoir increases in response to the large upstream loads of nutrients. 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 the processing of nutrients and the production of algae (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b). 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 dynamics 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 result is that the percentage of flow in the lower basin compared to the upper basin is considerably greater. For example, flows at Iron Gate dam are about 35 percent greater than flows at Keno dam. However, flows increase even more substantially downstream of Iron Gate dam, with flows in the Klamath River at the mouth (RM 7) greater by an order of magnitude than flows at Iron Gate dam (RM 190). Seasonally, summer period flow increases are not as substantial, 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	1,118%

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 190-mile long river reach is that the mainstem Klamath River channel is relatively "stable" in the upper 47-mile portion 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 190-mile lower Klamath River 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 is somewhat less.

4.2.10.2 Water Temperature

Water temperatures in the 190-mile lower Klamath River reach are generally at or near equilibrium water temperature conditions with the exception of immediately below Iron Gate dam (as described in section 4.3.9 above) 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 intake elevation that is about 30 feet below the reservoir water surface. These attributes lead to water temperatures that may be at or slightly below equilibrium water temperature during the spring period (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 water temperature due to the thermal lag caused by the reservoir's mass. The effect of this seasonal lag is largest in the river just below Iron Gate 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 (Figure 4.2-23).

Water temperatures are generally at or near equilibrium water temperature conditions over the rest of the lower Klamath River 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 (Sutton et al. 2002). By the time waters reach the Scott River (RM 142.9), water temperatures indicate minimal seasonal thermal lag and variability in mean daily water temperatures are largely absent, but results may vary among months (Perry et al. 2011).

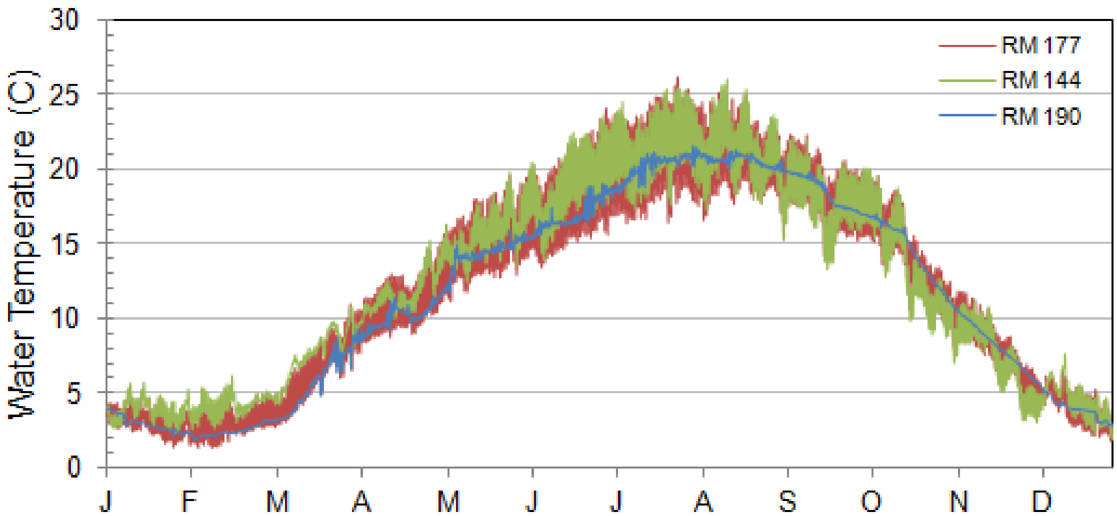


Figure 4.2-23. Water temperatures from hourly model simulations for example year 2004 for the Klamath River below Iron Gate reservoir (RM 190), above the Shasta River (RM 177), and above the Scott River (RM 144).

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 reach 30°C and daily minimum temperatures in the 20° to 25°C range are common in this reach during summer (Figure 4.2-24). 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. As the river approaches the coast, marine influences can moderate river temperatures, but when clear warm conditions prevail, water temperatures respond accordingly. For example, water temperatures at Turwar (RM 6) are cooler overall during spring and summer periods than upriver at Orleans (RM 57) or Seiad Valley (RM 129), with the diurnal range in temperature also more moderated at Turwar (Figure 4.2-24). During winter, water temperatures at Turwar are generally warmer overall than at upriver locations (Figure 4.2-24) due to more mild meteorological conditions at lower elevations. Climate change analyses completed by Perry et al. (2011) indicate that water temperatures will most likely increase in the Klamath River system from less than 1°C to greater than 2°C by 2061. These temperature increases are expected to occur throughout the system, with the exception of local influences from large spring sources or selected tributaries.

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

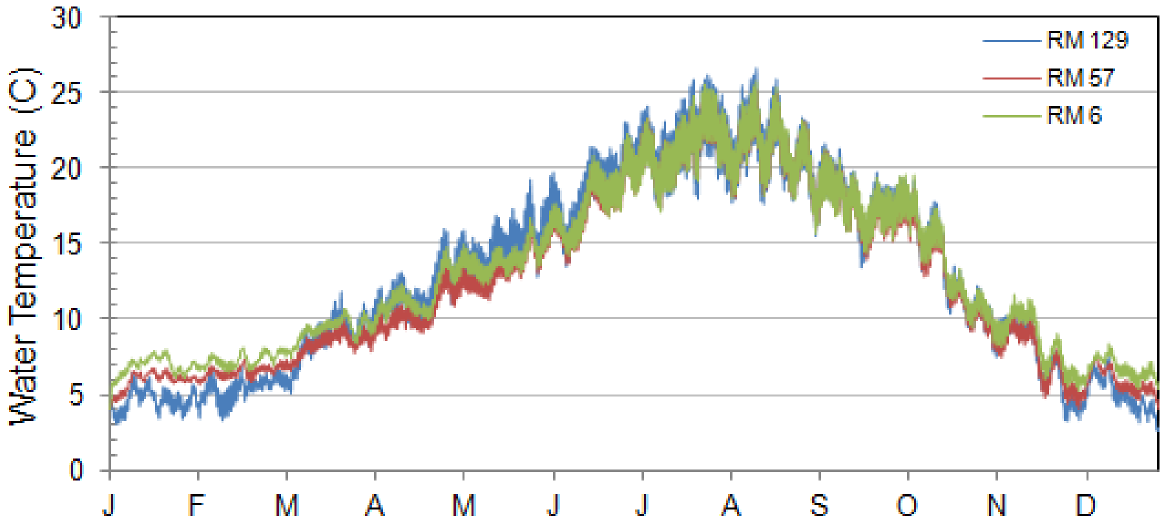


Figure 4.2-24. Water temperatures from hourly model simulations for example year 2004 for the Klamath River at Seiad Valley (RM 129), at Orleans (RM 57), and at Turwar (RM 6)

4.2.10.3 Nutrients and Algal Production

Waters flowing downstream carry a variety of particulates and nutrients from the headwaters to the terminus of the river system. However, nutrients (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; that is, organic matter breaks down into its components as it moves downstream; aquatic plant life extracts inorganic forms of 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. For example, Asarian et al. (2009) determined that Iron Gate and Copco reservoirs in combination retained about 58 metric tons of total phosphorus (about 11 percent of the inflow load) and 678 metric tons of total nitrogen (about 12 percent of the inflow load). Reservoirs can also transform incoming nutrients (e.g., as organic and inorganic particulate and dissolved matter) into dissolved organic and inorganic forms (Ward and Stanford 1983). The incoming and transformed nutrients support primary production within the reservoir as well as in river reaches downstream of the reservoir.

Field observations support these concepts. The concentrations of nitrate and orthophosphate are steadily reduced with distance from Iron Gate dam (for example, Figure 4.2-1 shows a steady downriver decline in DOC, total phosphorus, and total nitrogen along Klamath River monitoring sites from RM 189.7 near Iron Gate dam to the mouth). 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 the Salmon and Trinity Rivers (for example, these locations correspond to approximately RM 59.1 and RM 43.5 monitoring locations, respectively, represented in Figure 4.2-1). The decrease in rate of nutrient reduction 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, dilution, annual disturbance due to sediment transport, or other factors.

Nutrient concentrations also indicate seasonal variations with lower concentrations in early spring, increasing through summer and fall (Deas 2008, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013). This condition is probably due to both dilution from tributaries during the wetter months as well as seasonal fluxes from upstream during warmer months.

Algal taxa in the 190-mile Klamath River reach below Iron Gate dam consist of phytoplankton, attached algae (periphyton), and rooted aquatic macrophytes. Phytoplankton show a general trend where diatoms dominate much of the year, with cyanobacteria (blue-green algae) increasing to appreciable numbers in summer and early fall (Raymond 2008b, Raymond 2009b, Raymond 2010b, Watercourse 2011b, Watercourse 2012, Watercourse 2013). In general, the abundance of phytoplankton declines significantly as the river flow downstream from Iron Gate dam to the estuary, because the river generally does not provide suitable habitat for phytoplankton that perform better in lentic (i.e., reservoir and lake) environments.

Cyanobacteria phytoplankton species, including *Microcystis* and *Anabaena*, have been observed throughout the river downstream to the Klamath Estuary, but are present in considerably lower abundance in the river downstream than in upstream lakes and reservoirs (Figure 4.2-25). It is not known the extent to which cyanobacteria phytoplankton are independently producing and growing in the river downstream, particularly in slower moving part of the river, river backwater areas, or the estuary area near the mouth that provide suitable conditions for growth of cyanobacteria.

Despite the declining abundance of cyanobacteria phytoplankton in the river downstream (Figure 4.2-25), the algal toxin microcystis is a concern in the river because it has been detected at times throughout the lower 190-mile Klamath River reach. Measured concentrations of microcystin in the lower river have at times exceeded the guidelines (SWRCB 2010) for posting public health advisories.

Benthic algae (periphyton) in the Klamath River are dominated by attached eutrophic diatoms and filamentous green algae (Eilers 2005b, Asarian et al. 2010, NCRWQCB et al. 2005). Eilers (2005b) identified periphyton conditions in the Klamath River between Iron Gate dam and the mouth of the Salmon River (RM 67). Eilers (2005b) observed that periphyton coverage and periphyton chlorophyll content started high in the river downstream from Iron Gate dam and then increased gradually to peak levels in the river near the Salmon River. Monitoring data indicates there are sufficient nutrients to support a significant benthic algae (periphyton) community below Iron Gate dam, with high concentrations in the river from Iron Gate dam to near Orleans (for example, Figure 4.2-1 shows relatively high box plot values of total phosphorus and total nitrogen at sites from RM 189.7 near Iron Gate dam to RM 59 near Orleans).

Periphyton assemblages in the lower Klamath River below Iron Gate dam evolve through the growth season, reflecting nutrient distributions mentioned previously, and reflect nutrient dynamics in a predictable manner. Specifically, during spring, the periphyton assemblage includes a wide range of eutrophic diatoms, including the more prevalent species *Cocconeis placentula*, *Nitzschia frustulum*, *Navicula cryptocephala veneta*, and *Rhoicosphenia curvata*. However, proceeding into summer, nitrogen limitation in the lower river favors species adapted to such conditions (Stancheva et al. 2013), and *Epithemia sorex* dominates in the lower river after August.

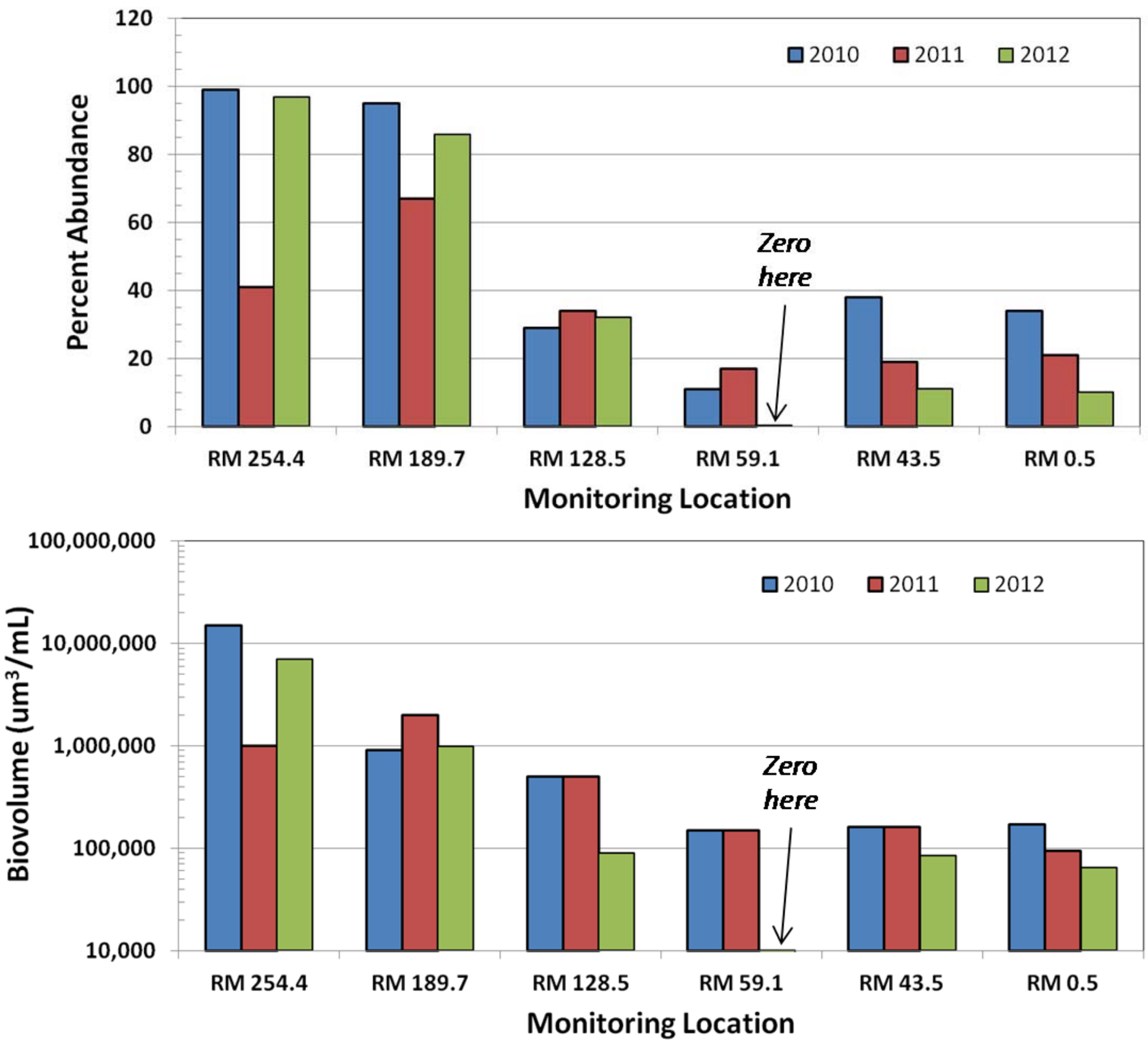


Figure 4.2-25. Cyanobacteria (blue-green algae) percent abundance and biovolume in mid-summer samples during recent monitoring (2010-2012) at six sites, including Link River dam (RM 254.4), the Klamath River below Iron Gate dam (RM 189.7), at Seiad Valley (RM 128.5), at Orleans (RM 59.1), at Weitchpec (RM 43.5), and the Estuary (RM 0.5). Sources for data: Watercourse 2011b, Watercourse 2012, Watercourse 2013.

NCRWQCB et al. (2005) and Asarian et al. (2010) documented a shift in periphyton community composition in the Klamath River, where nitrogen-fixing species were not present directly downstream of Iron Gate dam but began to appear by Seiad Valley (RM 128) and then made up an increasing percent of periphyton biomass at sites downstream. NCRWQCB et al. (2005) and Asarian et al. (2010) observed that nitrogen-fixing species were dominant at sites between Orleans (RM 59) and Turwar (RM 6). The increased prevalence of nitrogen-fixing periphyton coincides with low levels of inorganic nitrogen (ammonia and nitrate) concentrations in water samples from sites below Orleans (NCRWQCB et al. 2005, Asarian et al. 2010, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013).

The majority of the rooted aquatic macrophytes in the Klamath River below Iron Gate dam occurs above the Scott River (RM 143.6). 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 rooted aquatic vegetation growth during late spring through early fall. During winter periods (low temperature and low light), rooted aquatic vegetation growth is largely reduced or absent. Downstream of the Scott River, active alluvial channel processes appear to limit rooted aquatic vegetation, with the attached benthic algae limited to periphyton. Rooted aquatic vegetation below the Scott River is typically limited to backwater areas or is absent altogether.

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

Dissolved oxygen concentrations in the lower 190-mile Klamath River reach generally vary from approximately 7.0 to 12.0 mg/L during the year (Figure 4.2-26). The annual trends and ranges in dissolved oxygen concentrations are generally consistent as waters travel downriver due to the many cascades, rapids, and riffles present in the river that provide mechanical reaeration. The exception is the relatively short portion of the reach just below Iron Gate dam. As described in section 4.2.9.4 above, the dissolved oxygen levels in the releases to the river from Iron Gate dam are typically more variable, ranging from approximately 5.0 to over 12 mg/L in during the year.

With regard to dissolved oxygen saturation, dissolved oxygen is persistently and mildly sub-saturated throughout the 190-mile Klamath River reach (NCRWQCB 2010). NCRWQCB (2010) conducted a river-wide assessment of DO saturation and determined that full saturation (100 percent) in the Klamath River in California is physically impossible to achieve under natural barometric pressures and water temperatures in the basin. As a result of this assessment, NCRWQCB (2010) proposed site-specific dissolved oxygen objectives for the Klamath River in California that vary from 85 to 90 percent saturation depending on season and location (sub-reaches) along the lower 190-mile Klamath River 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 lower 190-mile Klamath River reach (PacifiCorp 2004e, PacifiCorp 2008b). Unlike the water from Upper Klamath Lake, 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 flow 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 the range of 8.5 to 9.0 in the early afternoon during late spring and summer periods in the reach between Iron Gate dam and Seiad Valley (Figure 4.2-26).

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

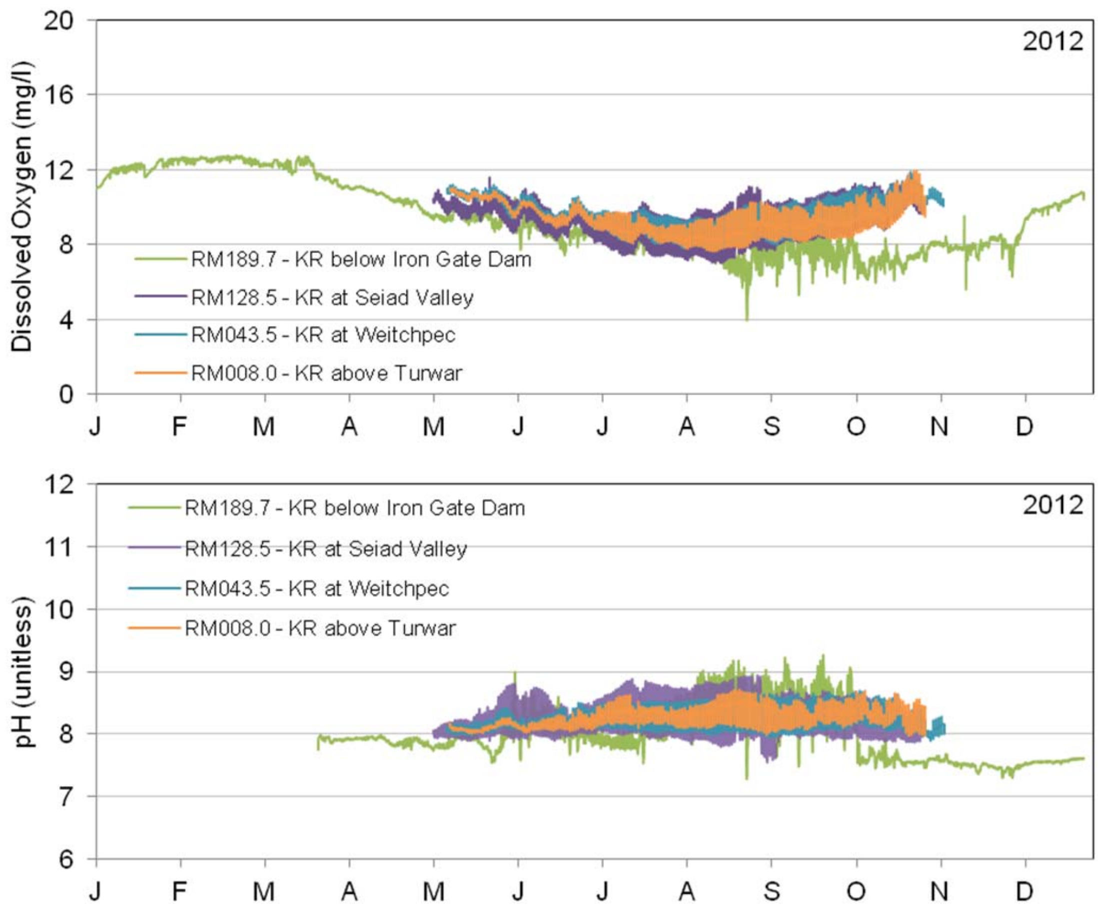


Figure 4.2-26. Annual trend in dissolved oxygen (upper plot) and pH (lower plot) during 2012 as measured in the lower Klamath River below Iron Gate dam (RM 189.7), at Seiad Valley (RM 128.5), at Weitchpec (RM 43.5), and above Turwar (RM 8). Continuous data was collected using datasondes.

4.2.10.6 Other-Tributaries

Tributary inflows contribute to the water quality conditions in the Klamath River downstream of Iron Gate dam (Figure 4.2-27). 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 the Scott River, provide direct dilution and generally improve water quality from upstream to downstream. However, even these other tributaries have impaired water quality at times. For example, the Salmon River is listed on the Section 303(d) List for impairment or threat of impairment to water quality associated with nutrients and water temperature (NCRWQCB 2005). As another example, blue-green algae blooms have been observed in recent years in the Trinity River (Hostler 2012).

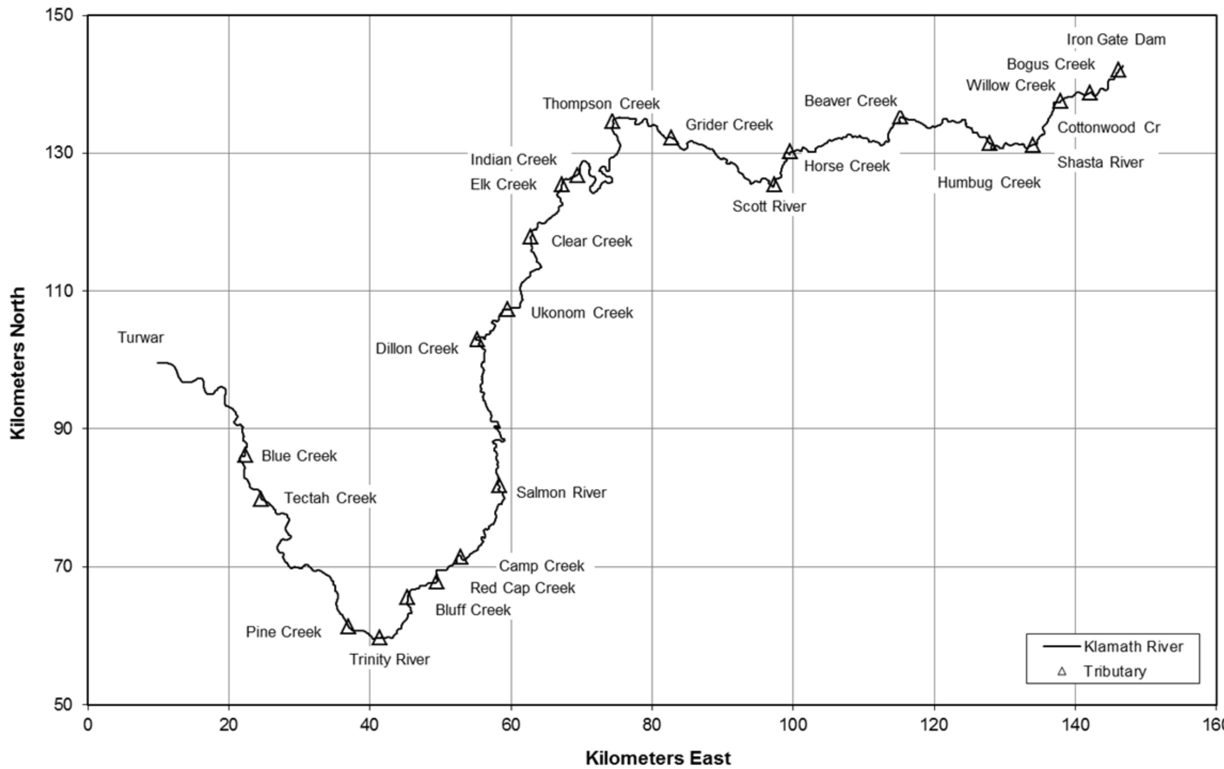


Figure 4.2-27. Iron Gate Dam to Turwar Reach Representation Showing Selected Tributaries.

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 more 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 nutrients 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 from Upper Klamath Lake 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 the migratory pathway to the basin, 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 tidal dynamics and a large, permeable bar consisting of sand and gravel. The mean annual flow at the mouth of the Klamath River at Klamath, California 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 on the Trinity River, located approximately 115 miles upstream from the confluence with the Klamath River, has 2.4 million acre-feet of storage, and operations on the Trinity River could possibly provide some level of flow management. This aspect of flow and water quality management has not been fully explored at this time. However, releases from the Trinity River have occurred in recent years (2012 and 2013) during the late summer to mitigate fish disease conditions that can develop in the lower river with large in-river fall Chinook returns.

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 upriver. 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, 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 (salinity), meteorological conditions, and perhaps other factors. Temperature and salinity are closely related and during the warmer periods of the year when denser, cooler waters from the ocean are present in the estuary, they form a cool, saline salt wedge (Hiner 2006). The result is a both thermal and salinity stratification, where the thermocline and halocline are roughly coincident. If the salt wedge is absent, the estuary is generally isothermal. 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. Nonetheless, ongoing efforts are shedding insight into this complex environment (Hiner 2006, Yurok Tribe 2010, Yurok Tribe 2011, Yurok Tribe 2012, Yurok Tribe 2013). Klamath River nutrient levels generally are at their lowest concentrations at the downstream-most portion of the 190-mile reach of the lower Klamath River from Iron Gate dam to Turwar. Estuary inflow ammonia and nitrate levels are typically low while orthophosphate levels are at sufficient levels for primary production to occur when nitrogen is available. Seasonal variation in nutrient levels in these inflows occurs, although not as marked as in upstream reaches. Total phosphorus and total nitrogen concentrations during summer and fall (June-September) are typically below 0.1 mg/l and 0.6 mg/l, respectively (Yurok Tribe 2011). The estuary provides another opportunity for phytoplankton growth due to the relatively quiescent environment compared to the river, probably supporting a diverse assemblage of species adapted to fresh, brackish and/or marine conditions. Primary production dynamics are not completely defined spatially or temporally, but certain sloughs and similar areas in the estuary can exhibit eutrophic conditions (Yurok Tribe 2013).

4.2.11.4 Dissolved Oxygen

Dissolved oxygen conditions in the estuary are generally at or near equilibrium, but vary temporally and spatially. 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 (Wallace 1998). These conditions can be exacerbated by a salinity gradient (halocline), leading to stratification of the estuary with denser, and often cooler, saline waters occupying the deeper portions of the estuary (Wallace 1998). Backwaters and heavily vegetated sloughs may also experience depressed dissolved oxygen conditions (Hiner 2006).

4.2.11.5 Alkalinity and pH

Inflowing river waters are weakly buffered but brackish waters may not be. However, alkalinity concentrations in the estuary are typically less than 100 mg/L (Yurok Tribe 2010, Yurok Tribe 2011, Yurok Tribe 2012) suggesting that even with the influence of sea water, the estuary remains weakly buffered. Specific conductance ranges from less than 100 µS/cm to over 8,000 µS/cm (Yurok Tribe 2010, Yurok Tribe 2011, Yurok Tribe 2012) depending on the whether the dominant influence is river inflows river (low values) or the ocean (high values). pH values are generally in the range of 7.5 to 8.5, with occasionally higher values (Yurok Tribe 2010, Yurok Tribe 2011, Yurok Tribe 2012). Diel pH variations of approximately 0.5 pH units are typical in summer and fall periods, and are likely in response to algal production in the estuary (USBR and CDFW 2012).

4.2.11.6 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 complex and 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 and nutrient loading from far up river can affect estuarine water quality under certain conditions.

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 water temperature conditions at Upper Klamath Lake. Deviations from equilibrium conditions 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 Upper Klamath Lake

The Klamath River is unique for a river of this size in that it has a hypereutrophic headwater condition. The condition results in large loads of organic matter and nutrients that impact water quality throughout the entire down-river 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 and sunny climate, there is the potential for the system to become very productive at certain times of the year.

Settling in Reservoirs

All reservoirs trap material and increase residence time (process time). Copco and Iron Gate reservoirs act as an 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 Upper Klamath Lake and the upper basin. Additionally, the reservoir detention times – on the order of 2 months - can also delay nutrient export from Upper Klamath Lake to the lower Klamath River such that those nutrient fluxes occur at the tail end of the algal growth season when nutrient export will contribute less to downstream water quality impairment.

4.3 PROJECT CONTRIBUTIONS TO WATER QUALITY

During the new license period, PacifiCorp proposes to operate its currently licensed facilities, except for the East Side and West Side Developments at Link River, which will be decommissioned, and Keno dam, which PacifiCorp proposes to exclude from the Project. Operations in the Oregon portion of the Project will continue at the J.C. Boyle Development, including load following (peaking) operations.

All Project facilities in California will continue to be operated as part of the Project. Operations will continue at the Copco No. 1 and Copco No. 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.

Copco and Iron Gate reservoirs are more effective than the river in retaining organic matter, especially particulate forms, and nutrients delivered from upstream sources, notably Upper Klamath Lake. The retention of organic matter and nutrients results in periodic abundant seasonal blooms of planktonic algae in the epilimnion[13] of the reservoirs. Organic matter associated with senescence of these blooms is largely

[13] The epilimnion is the top-most layer in a lake or reservoir during the time of year when thermally stratified. It occurs above the deeper, cooler hypolimnion. The epilimnion is warmer, and typically has higher pH and dissolved oxygen concentrations than the hypolimnion. Almost all algae and other plant growth occurs in the epilimnion, because the light is strong enough there for photosynthesis.

contained within the reservoir and can contribute to seasonal low dissolved oxygen in the hypolimnion of the reservoirs. This results in a net decrease in organic matter and nutrients that would otherwise be transported downstream and contribute to increased algae growth in the lower Klamath River below Iron Gate dam.

The periodic abundant seasonal blooms of algae in Copco and Iron Gate reservoirs include the cyanobacteria *Microcystis*. *Microcystis* is of particular interest because of its potential to produce toxins (e.g., microcystin) in the reservoirs that can present a public health risk (Raymond 2008b, Raymond 2009b, Raymond 2010b). Copco and Iron Gate reservoirs provide lacustrine conditions where these cyanobacteria grow. However, the abundant algae growth in the reservoirs is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake. In addition, *Microcystis* blooms in the Klamath Basin and the Project reservoirs are part of a rising incidence of toxin-producing cyanobacteria elsewhere in California and the U.S. (Lehman et al. 2013, CDPH 2013, Oregon State University 2013). Nevertheless, PacifiCorp proposes to implement a Reservoir Management Plan (Appendix B) for improving water quality in Copco and Iron Gate reservoirs. Actions implemented through the Reservoir Management Plan are aimed primarily at improving reservoir water quality conditions related to primary production from organic and nutrient loads contributed from sources upstream of the Project.

Iron Gate dam will continue to be operated in a modified run-of-river generation mode consistent with the schedule for instream flow releases and ramping rates as described in Reclamation's Klamath Project Operations Plans (consistent with the May 2013 Biological Opinion issued by NMFS and USFWS). PacifiCorp will continue to coordinate with Reclamation and NMFS to provide instream flow and ramping releases from Iron Gate dam that are consistent with applicable requirements stipulated in the 2013 Biological Opinion (NMFS and USFWS 2013). Per the 2013 Biological Opinion, Iron Gate flow release targets will continue to be adjusted on a daily basis in order to better mimic the natural flow variability in the Klamath River as detailed in the 2013 Biological Opinion (see Section 3.1.3.3).

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. In 2010, PacifiCorp adjusted instream flow releases in the Fall Creek bypass reach from 0.5 cfs to 5 cfs per IM 17 of the KHSA.

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 use 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, and

(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: (1) the A-dam is the City's primary diversion structure; and (2) the B-dam is the secondary diversion structure. The City intake is located at the A-dam which is located upstream from the California Department of Fish and Wildlife (CDFW) Fall Creek hatchery intake and downstream from the Fall Creek powerhouse on the PacifiCorp diversion. The B-dam is located in the natural channel below Fall Creek's lower waterfall. If the Fall Creek powerhouse trips offline, flow to the A-dam is reduced and eventually ceases. During these periods, the City opens the valve at the B-dam to divert water to the A-dam impoundment and intake 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 used for level control. Intake screens are located at the A-dam prior to the intake pipe. According to the City, year 2013 was a fairly typical year relative to the amount of water diverted to the City. Approximately 772 million gallons per year (2,210 acre-feet per year) of water was diverted from Fall Creek with the largest diversions occurring during July and August. Daily average diversion rates did not exceed 10 cfs and daily maximum diversion rates did not exceed 15 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 there is no evidence that the Project affects these uses or that the Project as operated under a new license would 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 affect 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 Upper Klamath Lake (see Section 4.0). Because the project does not adversely affect FRSH uses, no measures are proposed in this application to enhance this use. In addition, the Project's reservoir storage and ability to deliver specified flows to the Klamath River enhance the FRSH beneficial use, since surface water quantity in California would be less precise if delivered from the Link River Dam, 64 river miles upstream of Iron Gate dam.

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 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 Wildlife (CDFW), and the 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 levels 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 influenced by flows from Iron Gate dam. These flows levels are determined by Reclamation and set to achieve the flow-related requirements of Reclamation's biological opinions issued by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. These flows are largely set to enhance to protect listed species and meet Reclamation's tribal trust obligations. PacifiCorp coordinates with Reclamation on moving the flows through the Project to meet Reclamation'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 (PacifiCorp 2004h, PacifiCorp 2006, Raymond 2009a, Raymond 2009b, Raymond 2010a, Raymond 2010b, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013b). Blue-green algal blooms are common during summer not only in these reservoirs, but also in Upper Klamath Lake (Hoilman et al. 2008, Mioni et al. 2011, Caldwell-Eldridge et al. 2012, Eldridge et al. 2012). Increases in bloom-forming blue-green algae also have been identified in numerous other water bodies in California, including the Eel River, Van Duzen River, Clear Lake, Lake Elsinore, and San Francisco Bay Delta, among others (Lehman et al. 2013, CDPH 2013). Researchers at Oregon State University report that the levels of bloom-forming blue-green algae are rising nation-wide, and appear to be tied to rising temperatures and carbon dioxide concentrations due to climate change, and nutrient enrichment increases in runoff from urban and agricultural lands (Oregon State University 2013).

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 (PacifiCorp 2004h, PacifiCorp 2006, NCRWQCB 2010). 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)[14], 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. Systematic sampling by PacifiCorp and others have identified blooms of MSAE in the Project area reservoirs and elsewhere in the Basin both upstream and downstream of the Project area (Hoilman et al. 2008, Raymond 2009a, Raymond 2009b, Raymond 2010a, Raymond 2010b, Mioni et al. 2011, Caldwell-Eldridge et al. 2012, Eldridge et al. 2012, Watercourse 2012, Watercourse 2013b).

Under Interim Measure 15 of the Klamath Hydroelectric Settlement Agreement (KHSA), PacifiCorp provides funding of $500,000 per year for baseline and public health water quality monitoring, which includes blue-green algae and associated toxin monitoring that provides information used to notify the public, as necessary, relative to established public health guidelines. The monitoring data are used to track blue-green algae and associated toxin conditions that support management decisions to post and de-post public advisory notices at affected reservoir and river reaches in the Klamath Basin. This public health monitoring program is a cooperative effort of PacifiCorp, the Yurok Tribe, Karuk Tribe, and Reclamation.

PacifiCorp also has proposed and is implementing a Reservoir Management Plan (RMP) for the Copco and Iron Gate reservoirs (Appendix B). The RMP 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 RMP.

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[14] 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.

It is important to note that large loads of nutrient and organic matter from upstream sources, notably hypereutrophic Upper Klamath Lake, are the principal driver of algal blooms and associated water quality conditions in the Project reservoirs (PacifiCorp 2004h, PacifiCorp 2006, NCRWQCB 2010). PacifiCorp has no control of these large upstream loads of nutrients and organic matter, and any such control will need to occur from implementing appropriate TMDLs in the Klamath Basin. Klamath River TMDLs are being implemented by the Regional Board, in conjunction with ODEQ and EPA (NCRWQCB 2010, ODEQ 2010, ODEQ 2002). Successful implementation of TMDLs is necessary to bring about meaningful reductions in nutrient and organic matter from upstream sources and real improvements in water quality flowing into the Project area, and the implementation of TMDLs 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.

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, funding and implementing fisheries enhancement projects, and through funding of the Iron Gate Hatchery. These projects and measures have improved, and will continue to improve and enhance, fish production and habitat conditions in the Project area. These projects and measures will further benefit COMM uses. PacifiCorp will continue such support with the Project, and therefore will continue to protect 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. CDFW (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 Fisheries Enhancement Measures in the Klamath River

As previously described in Section 2.5.2 above, PacifiCorp filed the coho salmon HCP in February 2011 (PacifiCorp 2012) as part of an application for an ITP from NMFS. The coho salmon HCP identifies a process to implement measures that will avoid, minimize, and mitigate the effects of Project operations on coho salmon and attain the biological goals and objectives described in the HCP's coho conservation strategy. Such measures include: (1) implementing habitat enhancement activities through a Coho Enhancement Fund; (2) implementing flow releases according to Reclamation's Biological Opinion for Coho Salmon (NMFS and USFW 2013); (3) implementing turbine venting at Iron Gate dam to improve habitat conditions for coho salmon in the Klamath River; (4) funding research actions on Klamath River fish disease; (5) retrieval and passage of large wood debris trapped at PacifiCorp's facilities; and (6) monitoring to assess the benefits of these measures. On February 24, 2012, NMFS issued a final ITP that authorizes potential incidental take of coho salmon that could occur as a result of PacifiCorp's operation of the Project consistent with the terms of the HCP.

In addition to the fish habitat enhancement performed under the coho salmon HCP, PacifiCorp is funding and implementing additional habitat enhancements in the Klamath River above Copco reservoir. Under Interim Measure 7 of the KHSA, PacifiCorp provides funding of $150,000 per year for the planning, permitting, and implementation of gravel placement (or other habitat enhancement projects providing equivalent fishery benefits), including related monitoring, in the J.C. Boyle bypass and peaking reaches above Copco reservoir. Since 2011, approximately 1,600 cubic yards of gravel has been added to six sites. Monitoring is being conducted and additional sites for gravel placement are being evaluated for placement of additional gravel in the near future.

Under Interim Measure 8 of the KHSA, PacifiCorp funded and implemented the removal (in October 2012) of a rock barrier to fish movement in the J.C. Boyle peaking reach. The potential barrier was removed using a snatch block rigging system to remove rocks and boulders from the river channel above the high water line to create unimpeded fish passage.

5.1.10.3 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.

5.1.10.4 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 Hatchery for production of salmon and steelhead. 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 Hatchery is operated by CDFW. PacifiCorp owns the Iron Gate Hatchery and the current Project license requires PacifiCorp to fund 80 percent of Iron Gate Hatchery operations and maintenance costs, with the remainder provided by CDFW. However, under Interim Measure 18 of the KHSA, PacifiCorp has assumed funding 100 percent of these costs since 2010.

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. Since 2001, Iron Gate Hatchery has released an average of approximately 5.1 million Chinook salmon smolts and 900,000 yearlings (all fall-run fish) to the Klamath River each year (CHSRG 2012a). From 1999 to

2008, the numbers of fall-run Chinook adults returning to Iron Gate Hatchery averaged approximately 25,000 adults, ranging from a low run size of about 11,000 in 2008 to a high of about 72,000 in 2000 (CHSRG 2012a). Fall Chinook adults originating from Iron Gate Hatchery spawn naturally in Bogus Creek, Shasta River and the mainstem Klamath River, and currently make up about 35 percent of the natural spawning population in the mainstem Klamath River, 30 percent in Bogus Creek, and 10 percent in the Shasta River (CHSRG 2012a). Thus, naturally-spawning adults originating from the hatchery provide a significant portion of the fall Chinook natural spawner conservation objective of 35,000 and run-rebuilding objective of 40,700 in the Klamath River (CHSRG 2012a). Maintaining the current production at the hatchery will continue to provide these benefits.

Consistent with Interim Measure 18 of the KHSA, PacifiCorp purchased a fish marking system for the Iron Gate Hatchery to provide 25 percent constant fractional marking of Chinook salmon produced at the hatchery, which began in 2009. Previously, approximately 5 to 7 percent of Chinook at the hatchery were marked prior to release. The marking trailer was first used in the spring of 2011. The increased marking percentage at Iron Gate hatchery is expected to provide better data on the contribution of the hatchery to basin salmon escapement. PacifiCorp also worked closely with CDFW on the specification and purchase of a wet lab modular building to be used by CDFW for reading tag data on returning adult salmon. This building was completed in September 2012 and will improve acquisition of this important resource management information.

Increased tagging of 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.

5.1.10.5 Iron Gate Variable Flow Releases for Fisheries Enhancement

Under Interim Measure 5 of the KHSA, PacifiCorp has worked closely with Reclamation (in coordination with NMFS, USFWS, States, and Tribes) to provide variable flow releases from Iron Gate dam to benefit salmonids downstream of Iron Gate Dam. PacifiCorp has been implementing variable flow releases at Iron Gate dam consistent with the requirements of the joint Biological Opinion on Reclamation’s Klamath Project for 2013-2023 (NMFS and USFWS 2013), to shape flow releases at Iron Gate dam at certain times on the basis of the hydrograph of the Williamson River, a tributary to Upper Klamath Lake. Additional pulse flow events and other special flow releases may occur as requested by Reclamation following the recommendations of a technical group including NMFS, USFWS, States, Tribes, Reclamation, and PacifiCorp.

The joint Biological Opinion on Reclamation’s Klamath Project (NMFS and USFWS 2013), includes provisions for more variable flow releases from Iron Gate dam to provide benefits to listed species. PacifiCorp will be working closely with Reclamation to coordinate river operations and dam releases in a manner that achieves Reclamation’s flow requirements below Iron Gate dam while also meeting operational and other regulatory objectives of Reclamation and PacifiCorp.

5.1.10.6 Fish Disease Management

Under Interim Measure 6 of the KHSA, PacifiCorp established a fund in the amount of $500,000 in total funding to study fish disease relationships in the Klamath River downstream of Iron Gate dam. PacifiCorp consulted with the Klamath River Fish Health Workgroup regarding selection and implementation of research studies that were funded, including studies by Humboldt State University, Oregon State University, and the Karuk and Yurok Tribes. The focus of these studies was examination of how management actions could be improved to more effectively to reduce the incidence of the disease pathogen *Ceratomyxa shasta* (ceratomyxosis). Specific studies have included laboratory and field-based research to:

- Determine combinations of water hydraulics and sediment compositions that produce mortality in polychaetes;
- Measure the response of selected polychaete populations in the Klamath River to any experimental control actions over appropriate temporal and spatial scales;
- Determine the relative contribution of species-specific genotypes of *Ceratomyxa shasta* from tributary and mainstem sources and determine seasonal myxospore abundance;
- Develop mathematical models to improve the understanding of *Ceratomyxa Shasta* dynamics and provide opportunities for management (e.g., flow manipulation).

Results from these studies include several technical reports and a published journal article that are available on PacifiCorp's website under the Habitat Conservation Plan for Coho Salmon (http://www.pacificorp.com/es/hydro/hl/kr.html#). In the FEIS for the Project (FERC 2007), FERC staff concludes that if disease issues in the Klamath Basin are not addressed effectively in 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 (2007) 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, but rather indicates the low density of spawning in other reaches of the Klamath River below Iron Gate dam. 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, there does not appear to be a relationship between density of spawning fish and *C. shasta* infection. A pilot study that examined adult salmon carcasses in Bogus Creek found that the number of *C. shasta* myxospores varied between 3,000 and 14.7 million per gram of tissue examined (Bartholomew et. al. 2009), illustrating that the number of spores released by infected fish is highly variable. This demonstrates that high spore loading is not dependent on the density of infected spawners, but rather the number of highly infected individuals that are present. Thus, there is not necessarily a linear relationship between spawning density and spore loading; just a few highly infected individuals can result in high spore counts, regardless of overall spawning density.

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 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. This is because the reservoirs function to delay the downstream delivery of nutrient releases from upstream sources so that a portion of the nutrient release below Iron Gate dam occurs after the primary (May-Oct.) growth season. In addition, the reservoirs function to reduce nutrient advection downstream due to the settling of particulate-bound nutrients within the 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 relatively stable flow and bed conditions in the Klamath River above the Scott River compared to downstream reaches. (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 modest alluvial transport in this reach 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, in the J.C. Boyle peaking reach, and between Iron Gate dam and the Scott River.

Third, 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 water 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 below the confluence of the Scott River.

PacifiCorp's conclusions in this regard are supported by other recent independent analyses. In the 2006 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 (McKenna 2007). 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 ruled, based on the testimony of agency fisheries experts, that existing temperatures conditions will not preclude successful fall Chinook spawning and egg incubation (McKenna 2007). 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 criteria 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 (PacifiCorp 2004e). Electrofishing by CDFW (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 (PacifiCorp 2004e). 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 (PacifiCorp 2004e). 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 (PacifiCorp 2004e). There are few trout and large numbers of non-native fish, mostly yellow perch and crappie, along with bullheads. Electrofishing by CDFW (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 (2004e) 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 (PacifiCorp 2004e). 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 (PacifiCorp 2004e). 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. The Project supports COLD uses within or below the Project (PacifiCorp 2004e, PacifiCorp 2004h). Water quality conditions are generally sufficient to support a cold water ecosystem (PacifiCorp 2004h). 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 Upper Klamath Lake 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 the TMDLs that have been developed for the Klamath Basin (NCRWQCB 2010, ODEQ 2010, ODEQ 2002), 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 presented in the RMP for Copco and Iron Gate reservoirs (Appendix B) 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 (PacifiCorp 2004e, PacifiCorp 2004h). 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 2004h, 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 2004h). 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).

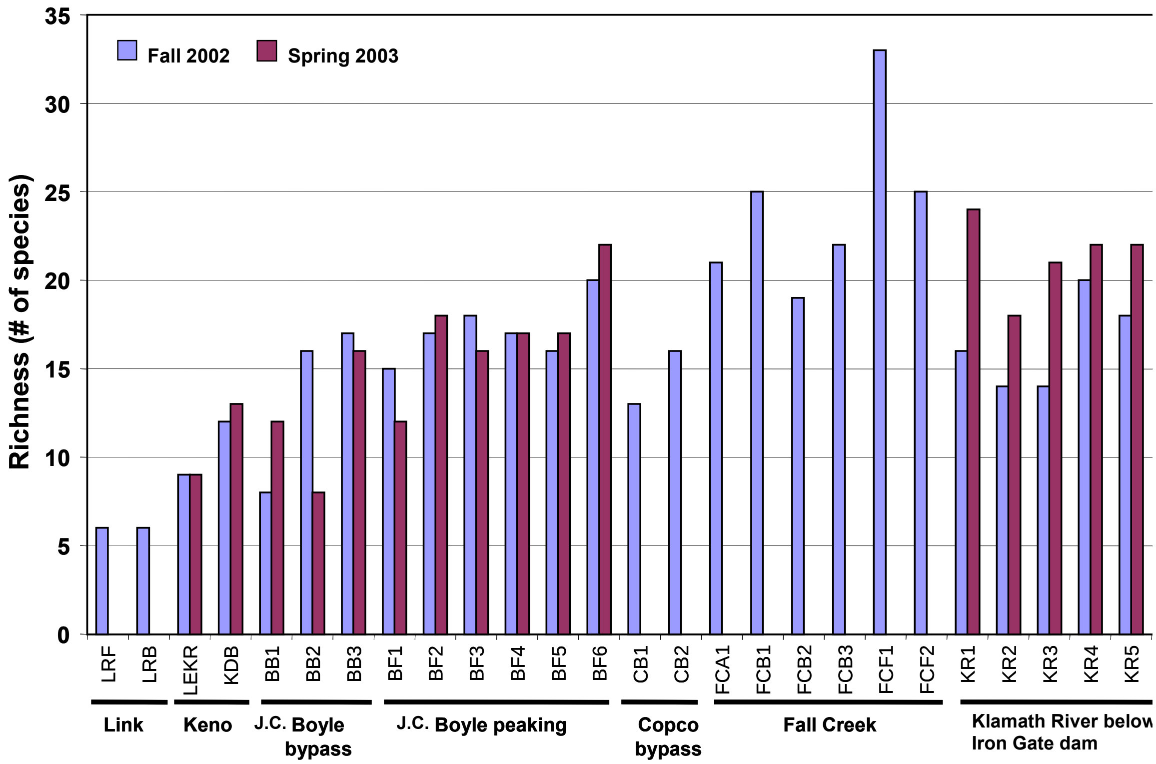

Figure 5.1-1. Taxa Richness (number of species) Observed During Fall 2002 and Spring 2003 Sampling of Macroinvertebrates at Several Location in Reaches in the Vicinity of the Klamath Hydroelectric Project.

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 (PacifiCorp 2004h). 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 2004h) and the FERC Final License Application, Volume 2, Exhibit E—Environmental Report (PacifiCorp 2004b). Section 8 of the Water Resources FTR (PacifiCorp 2004h) 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).

<u>Macroinvertebrate Drift Sampling</u>

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

<u>Fish in the J.C. Boyle Peaking Reach</u>

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 boundary (Stateline) 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 (2004e) 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 (PacifiCorp 2004e). 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 (PacifiCorp 2004e). 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 (PacifiCorp 2004e). 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 ((PacifiCorp 2004e). 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 (PacifiCorp 2004e). 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 summer/fall-run Chinook salmon, coho salmon, and include spring/summer-, fall-, and winter-run steelhead (NMFS and USFWS 2013, NMFS 2012a, NMFS 2012b, FERC 2007, PacifiCorp 2004e). Hardy and Addley (2001) also reported that chum and pink salmon still are captured infrequently in the lower Klamath River.

Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) in the Klamath River subbasin below Iron Gate dam consist mostly of fall-run Chinook salmon, including returning adults to Iron Gate Hatchery. Spring-run Chinook salmon also are present in this subbasin of the Klamath River, but they generally do not occur upstream past the confluence with the Salmon River (NMFS 2012a, NMFS 2012b).

In terms of abundance, fluctuations in run-size can vary widely and may be heavily influenced by ocean conditions during the ocean phase of the Chinook life-cycle (NMFS 2012b, PFMC 2014). Over the last 15 years, numbers of adult fall-run Chinook in the Klamath River basin have varied between 67,523 (in 2005) and 312,947 (in 2012) fish, with natural spawners representing about 27,857 (in 2005) to 133,359 (in 2012) of these totals (PFMC 2014). In 2013, the Pacific Fishery Management Council (PFMC) estimated the Klamath River Chinook run size at 165,140 adults with an estimate of hatchery returns of 17,149 adults and a total natural spawning escapement of 59,627 adults (PFMC 2014). In 2007, the PFMC enacted significant reductions in ocean and in-river harvest of Chinook adults as the numbers of estimated natural adult spawners in the Klamath basin fell short of the 35,000 target in 2004-2006, enacting restrictions on harvest. Since 2007, natural adult spawner escapement numbers in the Klamath basin have stabilized and strengthened to between 49,031 (in 2010) to 133,359 (in 2012) (PFMC 2014). In 2011, PFMC replaced the 35,000 spawning escapement floor with a management objective of 40,700 adults under requirements of a rebuilding plan (PFMC 2014).

The Shasta River has been the most historically important Chinook salmon spawning stream in the Klamath River subbasin, supporting an estimated spawning escapement of 30,700 adults as recently as 1964, and 63,700 in 1935 (PFMC 2008). Since 2000, the escapement to the Shasta River has varied from 962 adults in 2004 to 27,600 adults in 2012 (PFMC 2014). The most recent estimate of escapement in 2013 to the Shasta River was 8,021 adults, while estimated escapement to the Salmon and Scott Rivers was 2,480 and 4,624 adults, respectively (PFMC 2014). Of the 2013 total Klamath River system estimate, 38,586 (43 percent) adults were estimated to be Trinity River origin with most of these being naturally produced. The peak estimated in-river run of Klamath River fall Chinook of 312,947 adults in 2012 was the highest observed since 1978 (PFMC 2014).

In the mainstem Klamath River, 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 the 13.5 mile reach between Iron Gate dam and the mouth of the Shasta River. Similarly, CH2M HILL (1985) reported that the most important fall-run Chinook spawning areas in the mainstem Klamath River occurred between Iron Gate dam and the mouth of the Shasta River, and in the Bogus Creek near its mouth with the Klamath River downstream of Iron Gate dam.

Spring-run Chinook salmon, which were considered to be more abundant than fall-run fish prior to 1900, today consist of only remnant numbers (Hardy and Addley 2001). Spring-run Chinook salmon is now found only in the Salmon and Trinity River subbasins, and has varied in abundance 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).

Since 2001, Iron Gate Hatchery has released an average of approximately 5.1 million Chinook salmon smolts and 900,000 yearlings (all fall-run fish) to the Klamath River each year (CHSRG 2012a). Smolts are typically released in late May or early June, and most reach the estuary 1 to 2 months later. The subyearling and yearling releases show differences in survival rates to adult, with yearling releases exhibiting a higher average survival rate at 1.8 percent compared to 0.5 percent for subyearlings (CHSRG 2012a).

From 1999 to 2013, the numbers of fall-run Chinook adults returning to Iron Gate Hatchery averaged approximately 25,000 adults, ranging from a low run size of about 11,000 in 2008 to a high of about 72,000 in 2000 (CHSRG 2012a, PFMC 2014). Fall Chinook adults originating from Iron Gate Hatchery spawn naturally in Bogus Creek, Shasta River and the mainstem Klamath River, and currently make up about 35 percent of the natural spawning population in the mainstem Klamath River, 30 percent in Bogus Creek, and 10 percent in the Shasta River (CHSRG 2012a). Thus, naturally-spawning adults originating from the hatchery provide a significant portion of the fall Chinook natural spawner run-rebuilding objective of 40,700 in the Klamath River (CHSRG 2012a, PFMC 2014).

Most fall-run Chinook salmon adults returning to spawn in the Klamath River subbasin enter the mainstem from the ocean in late summer, with peak migration occurring in late August and early September (NMFS 2012a, NMFS 2012b). Fish enter the Scott River and other Klamath River tributaries beginning in September and continue to enter the tributaries through December. The peak of the upstream migration to the Scott River is in late October. Fall Chinook salmon reach their upstream spawning grounds within 2 to 4 weeks after they enter the river (NMFS 2012a, NMFS 2012b).

In the mainstem Klamath River, fall-run Chinook salmon alevins emerge from early February through early April, but peak times vary from year to year (NMFS 2012a, NMFS 2012b). After they emerge, fry disperse downstream, and many then take up residence in shallow water on the stream edges, often in flooded vegetation, where they may remain for various periods. As they grow larger, they move into faster water. Some fry, however, keep moving after emergence and reach the estuary for rearing.

In the Klamath River, the presence in late summer of lower temperatures at night and thermal refugia (i.e., pockets or pools of water at tributary mouths that are 1 to 4°C cooler than the mainstem) increase the ability of fry to grow and survive (NMFS 2012a, NMFS 2012b). Juvenile Chinook salmon continue to migrate downstream and are found in the Klamath estuary from March through September, over which time new arriving juveniles are constantly entering the estuary and older juveniles leaving to the ocean (NRC 2004).

The spawning migration of spring-run Chinook salmon adults to the Salmon and Trinity River subbasins typically begins in April and continues through June, rarely extending into August (NMFS 2012a, NMFS 2012b). The migrating adults typically reach their upstream spawning grounds in June and July. The adult fish hold in deep, cold, permanent pools in tributaries until spawning in the fall, generally in October and November. Emergence of spring-run Chinook salmon fry occurs in January and February. Outmigration of spring-run Chinook salmon fry and smolts in the Klamath River system occurs from February through mid-June.

Coho Salmon

In May 1997, NMFS listed Southern Oregon and Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) as Threatened under the ESA due to significant declines in population abundance and spatial distribution since the 1940's (62 FR 24588; May 6, 1997). NMFS designated critical habitat for SONCC coho downstream of Iron Gate dam in May 1999 (64 FR 24049; May 5, 1999). Within the Klamath River ESU diversity stratum of SONCC coho salmon, five populations of coho salmon are identified: Upper Klamath River, Middle Klamath River, Shasta River, Scott River, and Salmon River populations (Williams et al. 2006).

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 River population areas still support coho populations that may be native, while native coho runs are diminished in the tributaries in the Lower Klamath River population area (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.

Since 1998, Iron Gate Hatchery has released an average of 86,781 coho smolts to the Klamath River per year (CHSRG 2012b, CDFW 2014). 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 Hatchery have been highly variable. Since 1998, returns have ranged from 70 fish in 2009 to 2,466 fish in 2001 (CHSRG 2012b, CDFW 2014).

Coho salmon adults typically start to enter the Klamath River in September, peak migration occurs between late October and the middle of November, and a few fish continue to enter the river through the middle of December (NMFS 2012a, NRC 2004). Most spawning takes place in tributaries, but coho salmon have been observed spawning in side channels, tributary mouths, and shoreline margins of the mainstem Klamath River between Beaver Creek (RM 161) and Independence Creek (RM 94).

Coho salmon within the Upper Klamath River population spawn and rear primarily within several of the larger tributaries between Portuguese Creek and Iron Gate dam, namely Bogus, Horse, Beaver, and Seiad Creeks (NMFS 2012a). In this Upper Klamath River Population Unit, spawning has been documented in low numbers within the mainstem Klamath River. From 2001 to 2005, Magneson and Gough (2006) documented a total of 38 coho salmon redds between Iron Gate dam (RM 190) and the Indian Creek confluence (RM 109), although over two-thirds of the redds were found within 12 river miles of the dam. Many of these fish likely originated from Iron Gate Hatchery.

Ackerman et al. (2006) reported that spawning in the mainstem was limited to fewer than 100 fish. From 2001 to 2004, the estimated number of adult spawners returning to the Upper Klamath River Population Unit was 100 to 4,000. These estimated numbers are far lower than the 8,500 spawners needed for the low risk spawner threshold that Williams et al. (2008) defined for the Upper Klamath River. More recently, CDFW estimated that the minimum natural coho run size was only 664 fish in 2009 to the entire Klamath River (CHSRG 2012b). This number of fish is only 30 percent of the High Risk annual abundance level established for this population by NMFS (2010). A High Risk population is one where a species faces significant risks from internal and external processes that can drive a species to extinction (NMFS 2010)

Coho salmon fry start emerging in late February and typically reach peak abundance in March and April, although fry-sized fish appear into June and early July (NMFS 2012a, CDFG 2002). Some fry are captured in outmigrant traps at the mouths of the Shasta and Scott Rivers from March through May (Chesney and Yokel 2003). Juvenile coho salmon transform into smolts and begin migrating downstream in the Klamath River basin between February and the middle of June (NRC 2004).

Coho salmon parr and smolts rear within the mainstem Klamath River by using thermal refugia near tributary confluences to survive the high water temperatures and poor water quality common to the Klamath River during summer months (NMFS 2012a). Surveys by CDFG between 1979 and 1999, and 2000 to 2004, showed coho salmon were moderately well distributed downstream of Iron Gate dam in the Upper Klamath population area. Juveniles were found in 21 of the surveyed 48 tributary streams (NMFS 2012).

The Middle Klamath River Population Unit covers the area from the Trinity River confluence upstream to Portuguese Creek (inclusive). Coho salmon spawning surveys have been limited in the Mid-Klamath and therefore information on adult distribution is scarce. Spawning surveys by the Karuk tribe in 2003, 2004, 2007, and 2008 in some spawning tributaries found only a handful of redds and adult coho salmon each year (NMFS 2012b). Ackerman et al. (2006) estimated a run size of between 0 and 1,500 for this population unit (for estimates for the period from 2001 to 2004).

Ackerman et al. (2006) estimated the number of adult coho salmon returning to the Shasta River population unit at 100 to 400 annually. The size of the Scott River population unit is not precisely known, although Ackerman et al. (2006) estimated total run size for the Scott River basin at 1,000 to 4,000 in 2001, 10 to 50 in 2002 and 2003, and 2,000 to 3,000 in 2004.

Juvenile counts indicate that productivity is relatively low with fewer than 12,000 juvenile coho salmon found between 2002 and 2009 during surveys of mid-Klamath tributaries (NMFS 2012b). Many of these juveniles are likely from other populations and the actual number of juveniles of the Mid-Klamath population unit could be much lower. Most of the juvenile observations are of juveniles using the lower parts of the tributaries and it is likely that many of these fish are non-natal rearing in these refugial areas.

NMFS (2012a) concludes that the effects of Iron Gate dam on channel processes (e.g., recruitment of sediment and large woody debris) and water quality in the Klamath River diminish in the downstream direction as flow combines with tributary inputs. NMFS (2012a) indicates that, while the effects of Iron

Gate dam are minimal in this reach, they may combine with other factors to influence the coho salmon population.

Most migrating adult coho salmon are likely unaffected by elevated summer water temperatures characteristic of the Middle Klamath River section (NMFS 2012a). By late September when adult coho salmon migration begins, water temperatures are usually close to 19ºC throughout the Middle Klamath River section and decrease through the migration season.

NMFS (2012a) indicates that the quality and amount of spawning habitat in the Middle Klamath River reach is limited due to the geomorphology and the prevalence of bedrock in this stretch of river. Coho salmon are typically tributary and headwater stream spawners, so it is unclear if there was historically very much mainstem spawning in this reach.

Fluctuating dissolved oxygen concentrations in the Klamath River, such as those measured during summer 2004 at Weitchpec (RM 43.5), are common throughout the mainstem, resulting from high primary productivity fueled by naturally elevated water temperatures and the large loads of nutrients from upstream sources, notably Upper Klamath Lake (NMFS 2012a). For example, dissolved oxygen levels at Weitchpec during 2004 peaked above 10 mg/L for several days in mid-October, but were generally above 7 mg/L for most of the summer (NMFS 2012a). The exception was several days in both late August and early September, when dissolved oxygen levels as low as 5.5 mg/L were measured. NMFS (2010) concludes that disease effects likely have a substantial impact on the survival of juvenile coho salmon in this stretch of river. NMFS (2012a) further concludes that, because the Klamath River is highly productive, food resources likely are not limiting.

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

Steelhead

Historically, the Klamath River supported large populations of steelhead (*Oncorhynchus mykiss*), the anadromous form of rainbow trout. Steelhead were distributed throughout the mainstem and the principal tributaries such as the Shasta, Scott, Salmon, and Trinity River basins, and many of the smaller tributary streams (NMFS 2012b).

NMFS considers all steelhead in the Klamath River basin to be part of the Klamath Mountains Province ESU (2012b). Moyle (2002) describes two life history forms within this ESU, a summer run and a winter run. Hopelain (1998), however, concluded that there are three distinct runs of steelhead in the Klamath River basin: a winter run that enters the river from November through March, a spring run that enters the river from March through June, and a fall run that enters the river from July through October. Other reports appear to consider the fall run described by Hopelain to be a component of the winter run, based on a run timing of August through February given for winter-run steelhead by Barnhart (1994; as cited by NRC 2004).

Juvenile steelhead generally have a longer freshwater rearing requirement (usually from 1 to 3 years). Some individuals may remain in a stream, mature, and even spawn without ever going to sea; others migrate to the ocean at less than 1 year of age, and some may return to freshwater after spending less than 1 year in the ocean. Based on analysis of scales taken from returning adults, approximately 91 percent of Klamath River winter-run steelhead juveniles enter the ocean at age 2+, having spent two summers in freshwater (Hopelain 1998). Juvenile steelhead generally outmigrate from March through June, although smolts may outmigrate during nearly every month of the year. The Iron Gate Hatchery steelhead program was initiated in the late 1960s to mitigate for impacts to habitat and fisheries resulting from the construction of Iron Gate Dam (CHSRG 2012c). Steelhead production has varied substantially over the years, with a high of approximately 643,000 yearlings in 1970 to a low of about 11,000 yearlings in 1997. Steelhead yearlings are released from the hatchery from March 15 to May 1 each year.

The program's 200,000 yearling production goal was met in most years prior to 1991; however, the goal has not been achieved since that time (CHSRG 2012c).

Broodstock for the steelhead program at the Iron Gate Hatchery come from volunteer returns to the hatchery and represent both anadromous and resident life histories (CHSRG 2012c). Between 1970 and 1990, the average return of adult steelhead to the hatchery was approximately 2,500 fish (CHSRG 2012c). Adult returns to the hatchery have steadily decreased from 2002 through 2009. The most fish trapped at the hatchery was 617 in 2002, the fewest was 117 in 2009 (CHSRG 2012c).

Other Species of Importance

The federally and state-designated endangered shortnose sucker (*Chasmistes brevirostris*) 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.

Green sturgeon (*Acipenser medirostris*) is an anadromous species that also occurs in the Klamath River. The Klamath River population of green sturgeon is included in the Northern Distinct Population Segment (DPS) and also includes fish that spawn in Umpqua, Rogue, and Eel Rivers. Green sturgeon enter the Klamath River to spawn from March through July (NRC 2004). Most spawning occurs from the middle of April to the middle of June. Spawning takes place in the lower mainstems of the Klamath and Trinity rivers in deep pools with strong bottom currents.

Green sturgeon have been observed migrating into the Salmon River, but they are not thought to ascend the Klamath River beyond Ishi Pishi Falls (RM 66) (Moyle 2002, NMFS 2005). Juveniles stay in the river until they are 1 to 3 years old, when they move into the estuary and then to the ocean. Outmigrant juveniles are captured each year in screw traps at Big Bar (RM 49.7) on the Klamath River and at Willow Creek (RM 21.1) on the Trinity River (Scheiff et al. 2001). After leaving the river, green sturgeon spend 3 to 13 years at sea before returning to spawn, and they often move long distances along the coast (NRC 2004).

Pacific lamprey (*Lampetra tridentata*) is a federal species of concern downstream of Iron Gate dam (PacifiCorp 2004a). Pacific lamprey have been observed as far upstream as Iron Gate dam (Hardy and Addley 2001). However, no quantitative data are available on the status of Pacific lamprey in the Klamath River basin, although their distribution is believed to be generally similar to that of steelhead (Hardy and Addley 2001).

Pacific lamprey are anadromous nest builders that, like salmon, die shortly after spawning. They enter the Klamath River at all times of the year and cease feeding as they migrate upstream. Lamprey eggs hatch in approximately 2 to 4 weeks, and then the larvae (ammocoetes) drift downstream to backwater areas where they burrow into the substrate and commence feeding, tail embedded and head exposed, on algae and detritus (Kostow 2002). Juveniles remain in fresh water for 5 to 7 years before they migrate to the sea at a length of about 6 inches and transform into adults (Moyle 2002). They spend 1 to 3 years in the marine environment, where they parasitize a wide variety of ocean fishes, including Pacific salmon, flatfish, rockfish, and pollock.

Eulachon (*Thaleichthys pacificus*) or candlefish is a smelt that reaches the southern extent of its range in the Klamath River (Moyle 2002). Historically, large numbers entered the river to spawn in March and April, but they rarely moved more than 8 miles inland (NRC 2004). Spawning occurs in gravel riffles, and the embryos take about a month to develop before hatching. Upon hatching, the larvae are washed into the estuary. Moyle (2002) indicates that eulachon have been scarce in the Klamath River since the 1970s, with the exception 1988, 1989, and 1999, when they were moderately abundant.

In March, 2010 NMFS listed the Southern DPS, which includes the Klamath River population, of eulachon as threatened (75 FR 13012; March 18, 2010). NMFS issued a final rule designating critical habitat for the Southern DPS of eulachon on October 20, 2011 (76 FR 65324). The designation includes the Klamath River from the mouth upstream to the confluence with Omogar Creek, but it excludes lands of the Resighini Rancheria and Yurok Tribe.

NRC (2004) reports that coastal cutthroat trout (*Oncorhynchus clarkii clarki*) occur mainly in the smaller tributaries of the Klamath River within about 22 miles of the estuary. Sea-run adults enter the river for spawning in September and October, and juveniles rear in fresh water for 1 to 3 years before going to sea during April through June.

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; NRC 2004).

The NRC (2004) 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 (NRC 2004). 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

Instream Flows and Ramping Rates

As described in Section 3.2.2, PacifiCorp proposes instream flows and ramping rate measures pertaining to the Project facilities in California under the new license. (PacifiCorp is not proposing any modifications to its operation that would affect the Project's ability to meet Reclamation's flow requirements downstream of Iron Gate dam.)

Copco No. 1 Development

There are no instream flow and ramping rate requirements at the Copco No. 1 Development. As described in section 3.1.1.1, the Copco No. 1 Development has no bypass reach since the powerhouse is located immediately below the dam. In addition, the Copco No. 1 powerhouse discharges directly into the small, 0.3-mile-long Copco No. 2 reservoir. Therefore, specific instream flow and ramping rate releases are not needed at this development.

Copco No. 2 Bypass Reach

Under the new license, PacifiCorp proposes to release a minimum instream flow of 10 cfs from Copco No. 2 dam to this short (1.5-mile long) and narrowly confined bypass reach channel. PacifiCorp proposes to construct a new flow release facility at Copco No. 2 dam to monitor flows and provide automatic adjustments to maintain required flow releases. PacifiCorp proposes that Project-controlled flow increases will not exceed a down-ramp rate of 125 cfs per hour with the exception of conditions beyond the Project's reasonable control. To the 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.

Copco No. 2 Powerhouse Tailrace to Iron Gate Reservoir

The Copco No. 2 powerhouse tailrace discharges back to the Klamath River at the head end of Iron Gate reservoir. As such, there are no minimum instream flow releases or ramp rate restrictions needed at this point because Copco No. 2 powerhouse discharges directly into the headwaters of Iron Gate reservoir.

Klamath River below Iron Gate Dam

Under the new FERC license, PacifiCorp will continue to coordinate with Reclamation and NMFS to provide instream flow releases from Iron Gate dam that are consistent with applicable requirements stipulated in the Reclamation BA (Reclamation 2012) and the 2013 Biological Opinion (NMFS and USFWS 2013). Details regarding Iron Gate flow release targets to the Klamath River per the 2013 Biological Opinion are provided in section 3.1.3.3.

At the request of the Reclamation and during emergencies and unanticipated events, PacifiCorp may deviate from the Iron Gate dam release target. Emergencies may include, but are not limited to, flood prevention or facility and regional electrical service emergencies, and public and operational safety. Unanticipated events may include pulse flow releases from the dam to provide benefits to environmental and fish and wildlife resources and ceremonial flow releases for downstream Tribal ceremonies. PacifiCorp would coordinate closely with Reclamation should the need to deviate from the Iron Gate dam flow target be identified. Such emergencies and special situations occur infrequently, and are not expected to significantly influence flows downstream of Iron Gate dam.

PacifiCorp will maintain ramp rates of flow releases from Iron Gate dam as specified in the 2013 Biological Opinion (NMFS and USFWS 2013). As specified, flow releases will be ramped down (decreased) by no more than 150 cfs in 24-hours and no more than 50 cfs in any 2-hour period when flows are less than or equal to 1,750 cfs. Flow releases will be ramped down by no more than 300 cfs in 24 hours and no more than 125 cfs in any 4-hour period when flows are greater than 1,750 cfs, but less than 3,000 cfs. The 2013 Biological Opinion (NMFS and USFWS 2013) does not contain specific daily or hourly ramp rates when the flow releases at Iron Gate dam are greater than 3,000 cfs. Additional details regarding ramp rates of flow releases from Iron Gate dam per the 2013 Biological Opinion are provided in section 3.1.3.3.

In addition to the instream flows and ramping rates at Iron Gate dam as described above, PacifiCorp also is now implementing variable flow releases at Iron Gate dam consistent with flow directives issued by Reclamation. The recently-issued joint Biological Opinion on Reclamation's proposed Klamath Project operations for the period 2013-2023 includes provisions for more variable flow releases from Iron Gate dam to provide benefits to listed species (NMFS and USFWS 2013). PacifiCorp is working closely with Reclamation to coordinate river operations and dam releases in a manner that achieves Reclamation's flow requirements below Iron Gate dam while also meeting operational and other regulatory objectives of Reclamation and PacifiCorp.

Fall Creek Bypass

Under the new FERC license, PacifiCorp proposes a minimum of 5 cfs into the Fall Creek bypass reach plus a 15 cfs continuous flow downstream of the bypass confluence. In March 2014, PacifiCorp submitted a petition to the State Water Board under Water Code section 1707 to recognize the instream use of 5 cfs in the bypass reach. The State Water Board is currently processing the petition.

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[15] in Oregon, and Copco No. 1, Copco No. 2, and Iron Gate[16] dams in California, but also include provisions for collecting smolts at Link River dam[17] 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 Energy Policy Act (EPAct) trial-type proceeding[18] in 2006. 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 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

[15] 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.

[16] 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.

[17] PacifiCorp notes that smolt collection at Link River dam would not be applicable with the decommissioning and removal of East Side and West Side facilities.

[18] Section 241 of the Energy Policy Act (EPAct) amends section 4(e) and section 18 of the Federal Power Act (FPA) to provide that a license applicant and any party to a license proceeding is entitled to a determination on the record on any disputed issue of material fact with respect to mandatory conditions or prescriptions filed pursuant to section 4(e) or section 18, after a trial-type hearing of no more than 90 days.

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 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 the Project reach 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 generally agrees with FERC's FEIS analysis that recommends a trap-and-haul based adaptive management approach to reintroduction before making the substantial investment in volitional fishways at the various Project facilities that would be required by the Section 18 prescriptions. PacifiCorp nevertheless recognizes that the Section 18 prescriptions need to be addressed by FERC licensing of the Project.

Selective Withdrawal for Temperature Management

As described in Section 3.2.4 above, 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. In addition, the 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 have effects on the hatchery that would need to be addressed under such scenarios.

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's modeling results indicate that if releases from Iron Gate dam are managed to sustain decreased temperatures, 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 release water temperature, a maximum reduction of up to 10°C is possible, but would last only for a few days until the cold water pool is depleted. Nonetheless, there are opportunities to manage cool water releases to reduce water temperatures in downstream river releases for selected periods of time that may provide benefits to fish at certain life stages or during critical biological and/or fish disease management windows.

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 concurred with PacifiCorp's assessment of the limited coldwater release capabilities at Copco No. 1 and Iron Gate dams. FERC staff recommended 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 indicated that "emergency circumstances" would be if and when temperature conditions for downstream juvenile anadromous fish survival approach critical levels. In addition, FERC staff suggested 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 and early fall 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.

Gravel Augmentation

As described in Section 3.2.6, PacifiCorp proposes gravel augmentation measures to enhance salmon 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 monitoring of the added material over the life of the new FERC license. It is proposed that 3,500 cubic yards of spawnable gravel be placed in the reach just downstream of Iron Gate dam during every 10-year period of the new license. The results of PacifiCorp's geomorphology study (PacifiCorp 2004h) indicate that any Project effects 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.

PacifiCorp proposes that gravel augmentation would occur using a passive-placement approach. Passive placement assumes that gravel is supplied at a specific place that is also hydraulically suited for gravel entrainment and transport, and the gravel will be naturally dispersed to enhance habitat downstream (Bunte 2004). The proposed placement location is near the Lakeview Road Bridge (also known as the Iron Gate Hatchery Bridge) downstream from Iron Gate dam near River Mile (RM) 189.8. This location is immediately downstream of the dam, which will allow gravel to be placed: (1) in the area with existing large substrate and greatest coarsening effects of the dam; (2) at the upstream-most location, allowing gravel to be distributed downstream during peak flows; (3) on PacifiCorp property, which will eliminate the need to obtain private landowner approval for access; and (4) near a gravel stockpile area on PacifiCorp property.

Gravel will be placed as necessary based upon the frequency of gravel mobilization. The target for gravel augmentation will be to place 3,500 total cubic yards of gravel during each 10-year period. The frequency of gravel placement will be determined based on monitoring to determine whether previously placed gravel has dispersed downstream. It is estimated that flows in the range of 4,500 cfs are needed to initiate transport of gravel at the proposed placement site near Iron Gate dam, with a peak flow return interval of about 1.5 years. Evaluation of peak flows since the previous placement period and monitoring of gravel transport will determine whether gravel placement is necessary for any given year.

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 Hatchery for production of salmon and steelhead. 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 Hatchery is 100 percent funded by PacifiCorp and operated by CDFW. PacifiCorp will continue funding the production and operation costs of the Iron Gate Hatchery to meet production goals. The hatchery has been successful at meeting production goals in nearly all years (except for steelhead), and has contributed to the number of adult returns to the ocean and in-river commercial, tribal, and sport fisheries since the late 1960s. The facility has been largely free of disease outbreaks and other major sources of mortality. 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.

Broodstock selection has, and will continue to be based on procedures used by CDFW to minimize adverse genetic consequences to the hatchery stock and naturally spawning fish in the Klamath River. PacifiCorp will continue to work with CDFW in their efforts to improve production efficiency and effectiveness and to minimize conflicts between hatchery-reared and naturally-produced salmon and steelhead trout. For example, in 2010, a Hatchery and Genetic Management Plan (HGMP) for the Iron Gate Hatchery Coho Salmon Program was submitted to NMFS by CDFW following collaborative work among NMFS, CDFW and PacifiCorp to develop the application. The HGMP program's conservation measures, including genetic analysis, broodstock management, and rearing and release techniques, will maximize fitness and reduce straying of hatchery fish to natural spawning areas. The HGMP measures are anticipated to increase population diversity and fitness and reduce genetic divergence of the hatchery and naturally-spawning coho populations. In 2014, PacifiCorp plans to continue the HGMP development process by collaborating with NMFS and CDFW to develop HGMPs for the Iron Gate Hatchery Chinook salmon and steelhead programs.

In 2009, PacifiCorp purchased a fish marking system for the Iron Gate Hatchery to provide 25 percent constant fractional marking of Chinook salmon produced at the hatchery. The marking trailer was first used in the spring of 2011. The system uses automated fish-marking equipment that reduces handling stress on the fish compared to manual methods. 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.

<u>Reservoir Management Plan for Copco and Iron Gate Reservoirs</u>

As described in Section 3.2.3 above, PacifiCorp will implement 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 February 2008 (PacifiCorp 2008a). 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), and Reclamation (2000). 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, ODEQ 2010, NCRWQCB 2010). 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) established by the State of California's North Coast Regional Water Quality Control Board (NCRWQCB 2010) and ODEQ (2010). 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.

The RMP (see Appendix B) describes the specific planned activities and actions by PacifiCorp for further testing, design, and implementation of techniques for water quality improvements in Copco and Iron reservoirs. As described in the RMP, these actions include: (1) constructed wetlands conceptual design and implementation planning; (2) further evaluation of tailrace aeration and oxygenation systems; (3) design and implementation planning of in-reservoir oxygenation systems; (4) evaluation of epilimnion (surface water) mixing and circulation; (5) further evaluation of selective withdrawal and intake control; (6) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoirs; and (7) additional testing and controlled applications of SCP algaecide to treat localized areas (e.g., coves, embayments) in the reservoirs. PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on the specific planned activities and actions proposed by PacifiCorp in the RMP, including on the water quality objectives that are desired to be achieved in the reservoirs and in the Klamath River downstream of Iron Gate dam.

Other Fish Habitat Enhancements

As described in Section 2.5.2.2 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the coho HCP (PacifiCorp 2012). A key component of the HCP includes the selection and implementation of habitat enhancement actions and activities to benefit coho salmon below Iron Gate dam funded through PacifiCorp's Coho Enhancement Fund. The actions and activities implemented under the coho HCP will continue over the interim period until the dams are removed pursuant to the Klamath Hydroelectric Settlement Agreement, or, should dam removal not proceed, until a new FERC license is issued. Therefore, there is currently no plan to continue the coho HCP actions and activities under a new FERC license and the associated 401 water quality certification for the Project. However, it is expected that various fish habitat enhancements implemented under the coho HCP will be durable and provide biological benefits into the future even after the interim coho HCP actions and activities cease. As such, the future biological benefits from these interim actions are accounted for, as appropriate, in the evaluation of the proposed Project's protection of particular designated uses (as discussed in this Section 5.1) and water quality objectives (as discussed below in Section 5.2) as set forth in the Basin Plan.

Since 2009, PacifiCorp has provided funding of $3,060,000 into the Coho Enhancement Fund. Each year, PacifiCorp, NMFS, and CDFW coordinate to select projects to be funded and implemented to benefit coho salmon. In this time, 24 projects have been selected and implemented to benefit coho salmon. The actions and activities implemented under the coho HCP will continue over the interim period to include:

- Modifications to tributary mouths to ensure access by coho salmon for spawning and rearing, including removal of swimmer dams, gradient barriers, log jams, and other types of impediments;

- Activities to maintain cover and the complexity of refugia habitat features at tributary mouths used by rearing juvenile coho salmon from the Klamath River;

- Restoration projects to increase the amount of available refugia habitat on the mainstem Klamath floodplain (e.g., through channel re-alignment) by increasing the flow from adjacent tributaries that create coldwater refugia on the mainstem Klamath, or adding structures at the refugia sites to increase the duration and extent of the coldwater plume

- Restoration projects to increase the amount of, or quality of conditions in, coho salmon rearing habitat in the Klamath River mainstem, including side channels, or off-channel habitats (alcoves, ponds, and groundwater channels associated with the floodplain);

- Retrieval of LWD trapped at or near Iron Gate, Copco 1, and Copco 2 dams, and release of retrieved LWD pieces to the river channel below Iron Gate dam;

- Tributary channel enhancements and improvements to improve coho salmon movement and access (e.g., removal or functional upgrades of diversion structures or screens, channel modifications or impediment removal to improve flow and access);

- Water rights purchasing transactions to increase instream flows for passage to and from key tributary rearing areas in the Scott, Shasta, and Upper Klamath;

- Fencing to protect riparian areas and streambanks along reaches that provide important summer rearing habitat in tributaries of the Upper Klamath, Scott River, and Shasta River; and

- Funding of fish disease research projects to enhance understanding and fill knowledge gaps related to factors and conditions causing disease in coho salmon in the Klamath River.

As described in Section 2.5.2.2 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the Sucker HCP[19] (PacifiCorp 2013). The Sucker HCP (PacifiCorp 2013) identifies a conservation strategy consisting of substantial shutdown of the East Side and West Side hydroelectric developments, continued support for an important restoration project on the Williamson River Delta, and a protocol for implementing a Sucker Conservation Fund that will avoid, minimize, and mitigate take of listed suckers. After considering public comments on the application, USFWS issued a final Incidental Take Permit in February 2014 that authorizes potential incidental take of listed sucker species consistent with the terms of the Habitat Conservation Plan. Under the ITP, PacifiCorp will continue to operate its other Klamath River facilities, which consists of Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams. Effects to suckers from these facilities are understood to be low because of their distance from Upper Klamath Lake, which is the primary habitat of the Lost River and shortnose suckers.

In its evaluation of PacifiCorp's Sucker HCP, the USFWS determined that remaining incidental take of listed suckers occurring under the HCP following the shutdown of East Side and West Side is not likely to jeopardize the continued existence of listed sucker species. This is because the majority of remaining affected suckers are not part of reproducing populations since they reside in downstream reservoirs, which are outside of their historic range.

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.

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[19] In August 2011, PacifiCorp filed an application for an ESA Section 10 permit with USFWS, including a draft Habitat Conservation Plan, to address potential incidental take of sucker species that could occur during the interim period prior to Project removal. PacifiCorp submitted a final revised Habitat Conservation Plan to USFWS in 2013 (PacifiCorp 2013). The application was reviewed by USFWS and public comments on PacifiCorp's application were solicited.

The Project area supports a wide variety of wildlife species, including deer and elk, a several species of smaller mammals, birds, amphibians, and reptiles (PacifiCorp 2004g). 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 CDFW showed a single individual with a long-range migration pattern between the Shasta Valley in California and the forests to the west of Upper Klamath Lake 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 (PacifiCorp 2004g). 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 (PacifiCorp 2004g). 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 (PacifiCorp 2004g). 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 (PacifiCorp 2004b). 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.

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

As described in Section 5.1.12.2 above, SONCC coho salmon are listed as Threatened under the ESA due to significant declines in population abundance and spatial distribution since the 1940's (62 FR 24588; May 6, 1997). Within the Klamath River ESU diversity stratum of SONCC coho salmon, five populations of coho salmon are identified: Upper Klamath River, Middle Klamath River, Shasta River, Scott River, and Salmon River populations (Williams et al. 2006). 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 CDFW released its Draft Recovery Strategy for the Coho Salmon, including the Klamath River system.

SONCC coho salmon population and life history attributes are also described in Section 5.1.12.2 above. Suitable spawning and rearing habitat exists throughout the Klamath River; however, coho spawning in the mainstem Klamath River is uncommon, and most returning adults seek out spawning habitat within large mainstem tributaries, such as the Scott and Shasta rivers, as well as smaller mainstem tributaries throughout the basin (Williams et al. 2006). Between Iron Gate dam and Seiad Valley, coho salmon 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 (CDFW 2002, NMFS 2012a, NMFS 2012b).

As described in Section 5.1.12.3 above, PacifiCorp proposes a number of measures that will specifically benefit coho salmon.

Lost River Sucker

The Lost River sucker (*Deltistes luxatus*) 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.

The final designation of critical habitat for the Lost River sucker was published on December 11, 2012 (77 FR 73740). In the final designation, two critical habitat units were proposed including: Clear Lake and Gerber Reservoir and their major tributaries, Upper Klamath Lake and parts of the Williamson, Wood, and Sprague River, and the upper Klamath River from Link River dam to Keno dam. Areas in the Klamath River downstream from Keno dam were not proposed for designation as critical habitat because such areas do not contain physical or biological features essential for the recovery of the species.

The Lost River sucker is native to Upper Klamath Lake (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 Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake reservoir and its tributaries, and the Upper Klamath River, primarily upstream of Keno dam (PacifiCorp 2004e). Some individual suckers are found in the Project reservoirs; however, the USFWS BiOp for Project relicensing (USFWS 2007a) indicates that these individual suckers are not part of a large or self-sustaining population due to lack of spawning habitat in the mainstem Klamath River. USFWS (2007a) indicated that these sucker species do not inhabit the Klamath River below Iron Gate reservoir.

Lost River suckers are a long-lived species, with the oldest individual recorded as 43 years old when taken from Upper Klamath Lake (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 Upper Klamath Lake 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 Upper Klamath Lake 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).

As described in Section 5.1.12.3 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the Sucker HCP (PacifiCorp 2013) that will specifically benefit Lost River sucker.

<u>Shortnose Sucker</u>

The shortnose sucker is an endemic species to the Upper Klamath River basin (including Upper Klamath Lake 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. The final designation of critical habitat for the shortnose sucker is the same as described above for the Lost River sucker that was published on December 11, 2012 (77 FR 73740).

The only known native historical distribution of the shortnose sucker is in Upper Klamath Lake 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 Upper Klamath Lake (Dennis Maria, CDFW, Yreka 1991). USFWS (2007a) indicated that these sucker species do not inhabit the Klamath River below Iron Gate reservoir.

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 Upper Klamath Lake, 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 Upper Klamath Lake 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).

As described in Section 5.1.12.3 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the Sucker HCP (PacifiCorp 2013) that will specifically benefit shortnose sucker.

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 (PacifiCorp 2004g) 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 2008b). 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 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. As described in Section 5.1.12.3 above, PacifiCorp proposes a number of measures that will specifically benefit listed coho salmon. Also as described in Section 5.1.12.3 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the Sucker HCP (PacifiCorp 2013) that will specifically benefit listed Lost River and shortnose suckers.

There is no evidence or information to suggest that the Project adversely affects RARE 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 (2007) 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 need to be addressed by FERC licensing of 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 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.

NMFS (2012) Biological Opinion

In February 2012, NMFS issued a BiOp on PacifiCorp's coho salmon HCP (PacifiCorp 2012) to fulfill the requirements of ESA Section 7 consultation on the HCP. The BiOp addresses the effects on SONCC coho salmon of the Proposed Action of issuing an Incidental Take Permit (ITP) to PacifiCorp for two general categories of activities addressed in the HCP: (1) continued operation of existing Project facilities during the 10-year term of the ITP[20]; and (2) implementation of conservation measures detailed in PacifiCorp's coho salmon HCP (PacifiCorp 2012).

The NMFS (2012) BiOp concludes that implementation of conservation measures will both improve hydrologic dynamics in the mainstem Klamath River by more closely mimicking natural flow regimes, and improve a broad assortment of habitat conditions in the mainstem Klamath River and in select tributaries. The multifaceted array of habitat-based actions are expected to, in varying degrees, primarily increase survival across the egg-to-smolt life stages for coho salmon populations residing downstream from Iron Gate dam. Those actions include: implementation of mainstem water management actions prescribed by the NMFS (2010) BiOp on Reclamation's Klamath Project Operations; gravel and LWD augmentation; disease abatement actions; rearing habitat enhancements; actions to improve thermal refugia access and conditions; actions to reduce passage impediments to improve connectivity; actions to improve dissolved oxygen conditions below Iron Gate dam; and interrelated actions to increase the number (due to increased survivability) and fitness of hatchery fish through the Iron Gate Hatchery HGMP.

The NMFS (2012) BiOp further concludes that the continued interim operation of PacifiCorp's Project facilities will continue to have effects on SONCC coho salmon. However, operations-related effects are confined mainly to the Upper Klamath River population unit of coho salmon, and when combined with the HCP conservation actions, the Proposed Action will result in a net positive effect on the affected populations' viability and lower the risk of extinction as the permit term progresses. The NMFS (2012) BiOp notes that the improvements in viability and risk will accrue to population units in the upper portion of the Klamath basin, e.g., the Upper Klamath, Shasta and Scott River population units. NMFS (2012) expects that the Middle Klamath population unit will experience some improvement in early life stage growth and survival with targeted actions. However, NMFS (2012) does not anticipate significant

[20] The 10-year term of the ITP covers the expected interim period until the dams are removed or, should dam removal not proceed, until a new FERC license is issued.

improvements for Lower Klamath River population viability because: (1) the Project is not believed to adversely affect these populations; and (2) fewer HCP conservation actions will take place in the lower population unit as there is little connection between the Project and the need to minimize and mitigate for Project effects.

USFWS (2007) Biological Opinion

In December 2007, USFWS issued a BiOp for the Project (USFWS 2007) to fulfill the requirements of ESA Section 7 consultation on the proposed FERC relicensing of the Project. The USFWS (2007) BiOp addresses the effects of the proposed Project relicensing 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 proposed Project relicensing on the designated critical habitat for the northern spotted owl and bull trout, and the proposed critical habitat for the listed sucker species. Critical habitat for listed sucker species was subsequently designated in a final rule by USFWS in December, 2012 (Federal Register, Vol. 77, No. 238, December 11, 2012. p. 73740).

The USFWS (2007) BiOp concludes that the proposed Project relicensing 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 proposed Project relicensing 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.

<u>USFWS (2013) Biological Opinion</u>

In December 2013, USFWS issued a BiOp on PacifiCorp's sucker HCP (PacifiCorp 2013) to fulfill the requirements of ESA Section 7 consultation on the HCP. The BiOp addresses the effects on the federally-listed endangered Lost River sucker and shortnose sucker of the Proposed Action of issuing an ITP to PacifiCorp for two general categories of activities addressed in the HCP: (1) continued operation of existing Project facilities during the 10-year term of the ITP[21]; and (2) implementation of conservation measures detailed in PacifiCorp's sucker HCP (PacifiCorp 2013). The PacifiCorp (2013) sucker HCP describes the strategy for avoiding, minimizing, mitigating, and monitoring the impacts of the taking of the listed sucker species by the covered activities.

The USFWS (2013) BiOp concludes that authorization of the ITP would not jeopardize the listed suckers or adversely modify their critical habitat because: (1) the amount of authorized take under the proposed HCP is reduced substantially from historic levels; (2) most of the authorized take is of sucker eggs and larvae that are produced in large numbers annually; (3) sucker populations in the Project reservoirs are not self-supporting and are likely dependent on upstream source populations to maintain themselves; (4) were it not for the Project reservoirs, habitat for the Lost River and shortnose suckers would not exist below Keno dam; (5) none of the Lost River and shortnose suckers that occur in the Project reservoirs below Keno dam have adequate upstream access, and therefore these fish do not contribute to reproducing populations upstream that are essential for recovery; and (6) adverse effects to designated critical habitat by the Project are confined to Keno reservoir, which represents a small fraction (~1 percent) of the total amount of designated critical habitat for the two species.

5.1.15 <u>Marine Habitat (MAR)</u>

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

[21] The 10-year term of the ITP covers the expected interim period until the dams are removed or, should dam removal not proceed, until a new FERC license is issued.

loads of organic matter and nutrients to the river in the Project area from upstream sources, particularly Upper Klamath Lake. 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 at this time. However, there is no evidence that the species found in this reach currently are migratory and would 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 effects 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 at this time. Iron Gate dam has blocked anadromous fish passage since 1962.[22] 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.[23]

However, 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. Boyle dam and Keno dam[24] in Oregon, and Copco No. 1, Copco No. 2, and Iron Gate[25] 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 2006b). 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 need to be addressed by FERC licensing of the Project.

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.

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

[23] 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.

[24] 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.

[25] 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 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.

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 has implemented turbine venting to enhance dissolved oxygen conditions downstream of Iron Gate dam 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 Upper Klamath Lake 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*[26] (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.

[26] *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*.

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, analyses by PacifiCorp (2006), PacifiCorp (2004h), Kann and Asarian (2005), Kann and Asarian (2007), and Asarian et al. (2009) 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, notably Upper Klamath Lake. The reduction in organic matter and nutrients provided by the Project reservoirs likely decreases the 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 Upper Klamath Lake. In addition, the Iron Gate fish hatchery, which is 100 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. The transport of algae from Project reservoirs downstream of Iron Gate dam has been raised by basin Tribes as affecting their CUL beneficial uses. However, PacifiCorp anticipates that the implementation of the Reservoir Management Plan (RMP) for the Copco and Iron Gate reservoirs, as described in Appendix B, will improve algae conditions in Project reservoirs and result in the implementation of measures to reduce the entrainment of algae into the Iron Gate powerhouse intake, thereby addressing potential impacts to the CUL beneficial use related to algae conditions.

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

The North Coast Basin Plan, Table 3-1a, at page 3-9.00, establishes the following specific dissolved oxygen objectives for segments of the Klamath River within and below the Project:

Location	Percent Dissolved Oxygen Saturation	Time Period
Stateline to Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Scott River to Hoopa	90%	Year round
Hoopa to Turwar	85%	June 1 through August 31
	90%	September 1 through May 31

For other streams in the Middle Klamath HA, the specific dissolved oxygen objectives are 7.0 mg/L as a minimum and 9.0 mg/L as a 50 percent lower limit[27]. For other streams in the Lower Klamath HA, the specific dissolved oxygen objectives are 8.0 mg/L as a minimum and 10.0 mg/L as a 50 percent lower limit.

The percent-saturation objectives for the Klamath River (listed above) were added to the North Coast Basin Plan (as listed in Table 3-1a of the Basin Plan) in 2011 after NCRWQCB (2010) conducted a river-wide assessment of dissolved oxygen saturation and determined that full saturation (100 percent) in the Klamath River in California is physically impossible to achieve under natural barometric pressures and water temperatures in the basin. Prior to establishing the above percent-saturation objectives, the specific dissolved oxygen objectives for segments of the Klamath River within and below the Project were: (1) 7.0 mg/L as a minimum and 10.0 mg/L as a 50 percent lower limit for Klamath River above Iron Gate dam including Iron Gate and Copco reservoirs; and (2) 8.0 mg/L as a minimum and 10.0 mg/L as a 50 percent lower limit for Klamath River below Iron Gate dam.

Most of the research literature on the effects of dissolved oxygen on coldwater biota discusses dissolved oxygen in terms of concentration (in mg/L) rather than percent saturation. For example, Davis (1975) reported effects of dissolved oxygen on salmonids, indicating that at dissolved oxygen concentrations greater than 7.75 mg/L salmonids functioned without impairment, at 6.00 mg/L onset of oxygen-related distress was evident, and at 4.25 mg/L widespread impairment is evident. USEPA (1986) reported that for life stages other than embryos and larvae, no impairment was observed at dissolved oxygen levels of 8 mg/L, slight impairment was evident at 6 mg/L, moderate impairment at 5 mg/L, severe impairment at 4 mg/L, and acute mortality at 3 mg/L and lower. Low dissolved oxygen can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity (Carter 2005). Prolonged exposure to low dissolved oxygen concentrations can be lethal to salmonids. However, salmonids can tolerate low dissolved oxygen concentrations for short periods of time. For example, winter studies in Alaska on juvenile coho found all juvenile coho survived for 24 hours when dissolved oxygen concentrations were 3.1 mg/L and high survival was observed when juveniles were exposed for 4-5 days to a dissolved oxygen concentration of 3.2-3.3 mg/L (Ruggerone 2000). A study examining utilization of emergent wetlands by juvenile coho in the Chehalis River in Washington found that emigrating coho were surviving in freshwater wetlands at extremely low dissolved oxygen concentrations; although dissolved oxygen concentrations as low as 0.5 mg/L may have resulted in juveniles preferring to utilize better conditions elsewhere (Henning et al. 2006). Another study conducted in slough environments in Washington found coho surviving in late spring dissolved oxygen conditions as low as 4.8 mg/L while emigrating through the slough environments (Beamer et al. 2011).

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, primarily from Upper Klamath Lake. 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.

[27] The 50 percent lower limit represents the 50th percentile values of the monthly means for a calendar year; i.e., 50 percent of more of the monthly means must be greater than or equal to the lower limit.

Barometric pressure and natural ambient temperatures also significantly affect dissolved oxygen concentrations in the project area. 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 the elevation in the Project area, summer water temperatures, and the large organic load from upstream, natural dissolved oxygen concentrations can be less than full (100 percent) saturation.

Klamath River from Stateline to Copco Reservoir

This segment of the river is well oxygenated because of extensive large rapids and associated mechanical reaeration in this reach. Dissolved oxygen data were 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 to 2005 (PacifiCorp 2004h, PacifiCorp 2008b). Additional measurements were made approximately bi-weekly between June and November from 2007 to 2009 (Raymond 2008a, Raymond 2009a, Raymond 2010a) and approximately monthly year-round from 2010 to 2012 (Watercourse 2011b, Watercourse 2012, Watercourse 2013). These dissolved oxygen data are summarized in Table 5.2-1.

Table 5.2-1. Summary of Dissolved Oxygen Measurements Made in the Klamath River above Copco Reservoir (RM 206) from 2000 to 2006 and 2007 to 2009.

	Concentration (mg/L)	**Saturation (Percent)**
No. of values	93	92
Minimum	7.2	86
Mean	10.1	106
Median	9.9	104
Maximum	15.1	134

All dissolved oxygen values measured at this location during these years were greater than 7 mg/L and 85 percent saturation. The seasonal distribution of dissolved oxygen levels in recent years (2008 to 2012) in the Klamath River upstream of Copco reservoir near Shovel Creek (RM 206.4) is shown in Figure 5.2-1. Dissolved oxygen levels measured in recent years (2008 to 2012) as shown in Figure 5.2-1 indicate that dissolved oxygen levels have consistently exceeded 8.0 mg/L and 90 percent saturation.

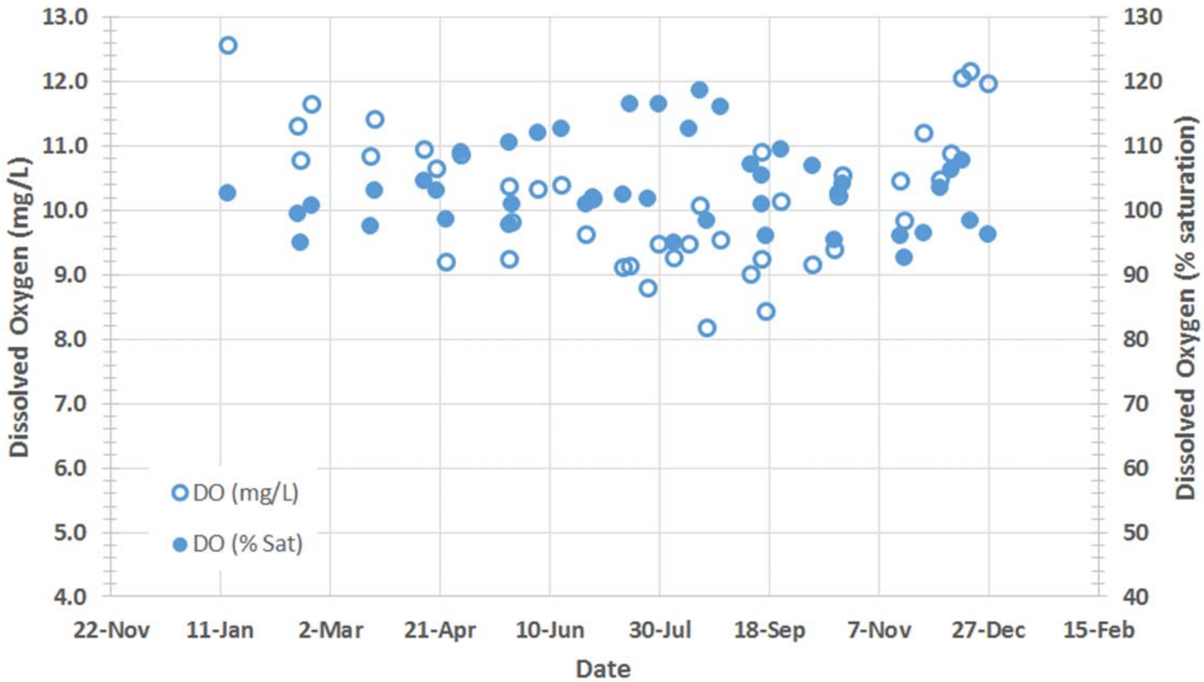


Figure 5.2-1. Values of dissolved oxygen (mg/L and % saturation) measured in the Klamath River upstream of Copco reservoir (RM 206.4) at various times of the year in 2008 through 2012.

Copco Reservoir Hydrologic Subarea

Vertical profiles of dissolved oxygen concentration were collected in Copco reservoir at approximately monthly intervals between March and November from 2001 through 2005 (PacifiCorp 2004h, PacifiCorp 2008b) and between June and November from 2007 through 2009 (Raymond 2008a, Raymond 2009a, Raymond 2010a). Example vertical profiles of dissolved oxygen measured in Copco reservoir are shown in Figure 5.2-2 and also in Figure 4.2-16 (in Section 4.2.8 above). Dissolved oxygen data for Copco reservoir are summarized by depth strata and season in Table 5.2-2. The three depth strata used in Table 5.2-2 include: (1) from the surface to 7-m depth; (2) between 7-m and 18-m depth; and (3) greater than 18-m depth. These three depth strata respectively approximate: (1) the near-surface photic or epilimnetic zone; (2) the metalimnion, including where the thermocline occurs during the period of stratification; and (3) the hypolimnion, including the reservoir volume below the thermocline during the period of stratification. For purposes of this analysis, the winter season includes the months December through March, the spring season includes the months April through June, the summer season includes the months July through September, and the fall season includes the months October and November.

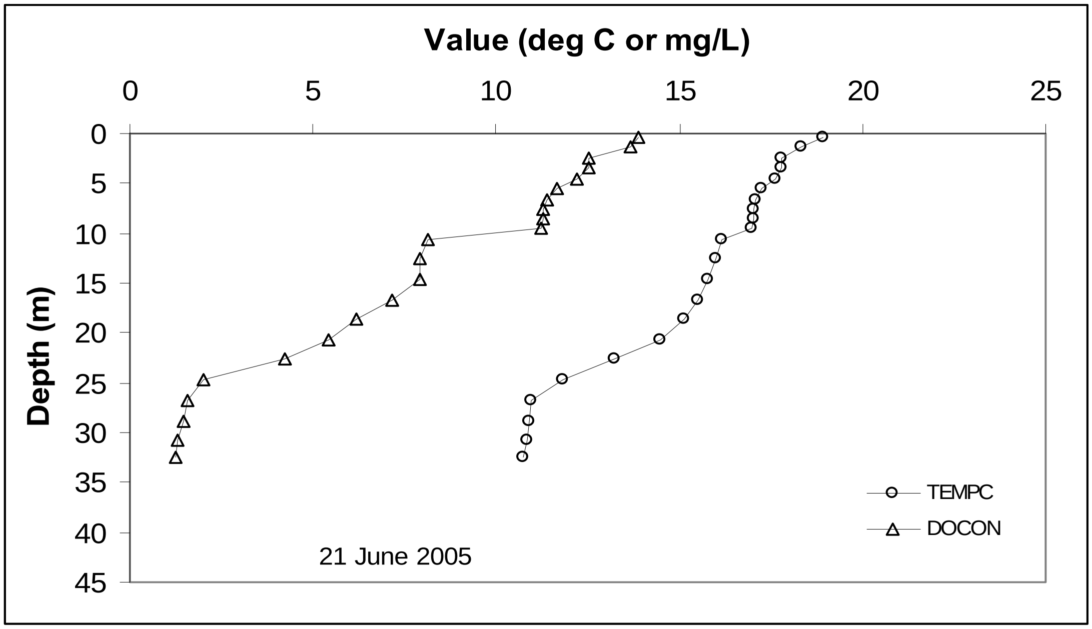


Figure 5.2-2. Vertical Profile of Temperature and Dissolved Oxygen from Copco Reservoir in June 21, 2005.

As the values in Table 5.2-2 indicate, dissolved oxygen conditions in Copco reservoir vary seasonally depending on the presence or absence of thermal stratification. During winter, when the reservoir is not stratified, dissolved oxygen throughout the reservoir is relatively high, with mean values exceeding 10 mg/L and 90 percent of all values exceeding 9 mg/L (Table 5.2-2). Variation in dissolved oxygen values between strata is most evident in spring and summer seasons when Copco reservoir exhibits seasonal temperature stratification (for example, see Figure 4.2-16 in Section 4.2.8 above). Seasonal stratification can act to impede mixing of bottom waters with surface waters in the reservoir. 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 lowering of dissolved oxygen in the hypolimnion. Low dissolved oxygen in the hypolimnion during stratification is a common phenomenon in eutrophic reservoirs and lakes (Welch 1992, Thornton et al. 1990, Horne and Goldman 1994).

Table 5.2-2. Summary of Dissolved Oxygen Measurements Taken in Copco Reservoir by Depth Strata and Season from 2005 through 2009.

Season	Depth Strata		
	0-7 m	**7-18 m**	**> 18 m**
Winter			
Count (n)	29	32	38
10th Percentile Value (mg/L)	9.2	9.1	9.1
Mean (mg/L)	11.0	10.7	10.4
Median (mg/L)	11.0	10.7	10.3
90th Percentile Value (mg/L)	11.9	11.7	11.7
Spring			
Count (n)	60	60	58
10th Percentile Value (mg/L)	8.4	5.0	0.7

Table 5.2-2. Summary of Dissolved Oxygen Measurements Taken in Copco Reservoir by Depth Strata and Season from 2005 through 2009.

Season	Depth Strata		
	0-7 m	**7-18 m**	**> 18 m**
Mean (mg/L)	9.8	7.8	4.2
Median (mg/L)	9.3	8.0	3.6
90th Percentile Value (mg/L)	12.0	10.6	8.5
Summer			
Count (n)	50	60	57
10th Percentile Value (mg/L)	6.5	1.1	0.3
Mean (mg/L)	9.7	4.3	1.3
Median (mg/L)	9.7	4.1	0.6
90th Percentile Value (mg/L)	12.1	7.5	2.1
Fall			
Count (n)	32	41	40
10th Percentile Value (mg/L)	7.8	6.5	2.8
Mean (mg/L)	8.6	7.9	6.6
Median (mg/L)	8.4	7.8	7.2
90th Percentile Value (mg/L)	10.0	9.8	10.4

During spring and summer, the presence of stratification results in low dissolved oxygen in the deeper portions of the reservoir. However, dissolved oxygen in the epilimnion of Copco reservoir remains relatively high. In spring, the mean of dissolved oxygen values in the epilimnion was 9.8 mg/L, with 90 percent of all values exceeding 8.4 mg/L (Table 5.2-2), and 100 percent of all values exceeding 85 percent saturation (Table 5.2-3). In summer, the mean of dissolved oxygen values in the epilimnion was 9.7 mg/L, with 90 percent of all values exceeding 6.5 mg/L (Table 5.2-2), and 96 percent of all values exceeding 85 percent saturation (Table 5.2-3). In fall, seasonal stratification subsides and the reservoir again returns to a more-mixed condition heading into winter. Slow deepening of the epilimnion allows hypolimnetic waters to reoxygenate from gradual mixing with the much larger, well-oxygenated epilimnetic volume. In fall, the means of dissolved oxygen values were 8.6, 7.9, and 6.6 mg/L in the epilimnion, metalimnion, and hypolimnion, respectively (Table 5.2-2).

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 Copco reservoir reflect the oxygen content that occurs in the epilimnion and above the thermocline. As such, the epilimnetic mean values (i.e., related to the 0-7 m depth strata) tend to represent the discharge concentrations of dissolved oxygen from Copco reservoir. The seasonal distribution of dissolved oxygen values in the Klamath River below the Copco 2 powerhouse is shown in Figure 5.2-3.

Table 5.2-3. Percent of Dissolved Oxygen Values Taken in Copco Reservoir that Equaled or Exceeded 6, 8, or 10 mg/L and 80, 85, and 90 Percent Saturation.

	Percent of Values that Equal or Exceed					
Season	**6 mg/L**	**8 mg/L**	**10 mg/L**	**80 % Sat**	**85 % Sat**	**90 % Sat**
Winter						
0-7 m depth	100	100	85	86	86	83
7-18 m depth	100	100	81	87	71	62
> 18 m depth	100	100	61	83	71	55
Spring						
0-7 m depth	100	97	43	100	100	97
7-18 m depth	82	50	23	65	57	37
> 18 m depth	29	20	0	14	7	0
Summer						
0-7 m depth	94	76	46	96	96	94
7-18 m depth	31	10	0	25	22	20
> 18 m depth	5	5	0	7	7	7
Fall						
0-7 m depth	100	75	16	78	59	39
7-18 m depth	95	44	10	52	28	25
> 18 m depth	73	33	15	23	20	17

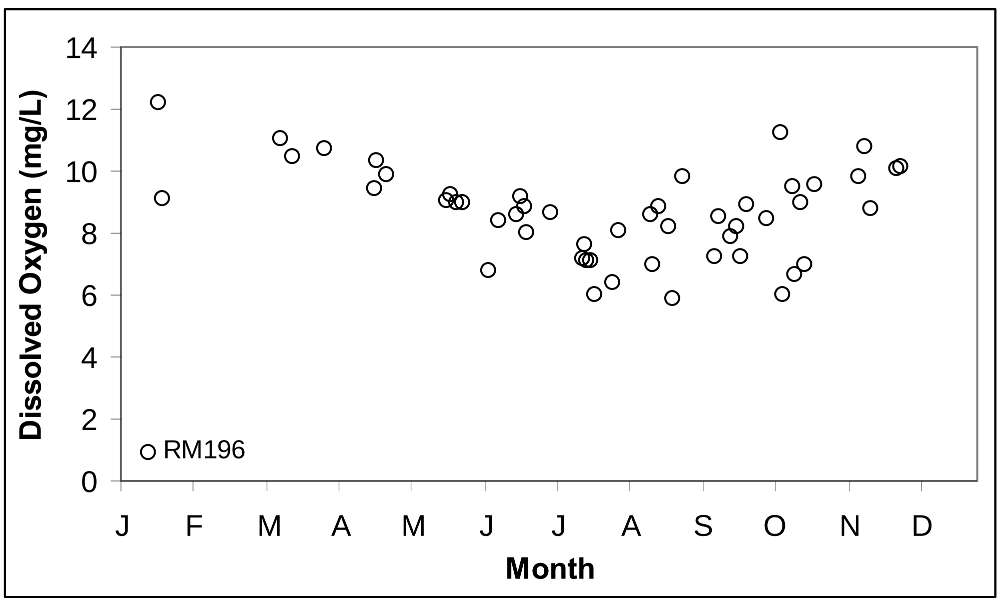


Figure 5.2-3. Values of dissolved oxygen measured in the Klamath below Copco 2 powerhouse (RM 196) at various times of the year in 2001 through 2007.

Iron Gate Hydrologic Subarea

Vertical profiles of dissolved oxygen concentration were collected in Iron Gate reservoir at approximately monthly intervals between March and November from 2001 through 2005 (PacifiCorp 2004h, PacifiCorp 2008b) and between June and November from 2007 through 2009 (Raymond 2008a, Raymond 2009a, Raymond 2010a). Example vertical profiles of dissolved oxygen measured in Iron Gate reservoir are shown in Figure 5.2-4 and also in Figure 4.2-19 (in Section 4.2.8 above). Dissolved oxygen data for Copco reservoir are summarized by depth strata and season in Table 5.2-4.

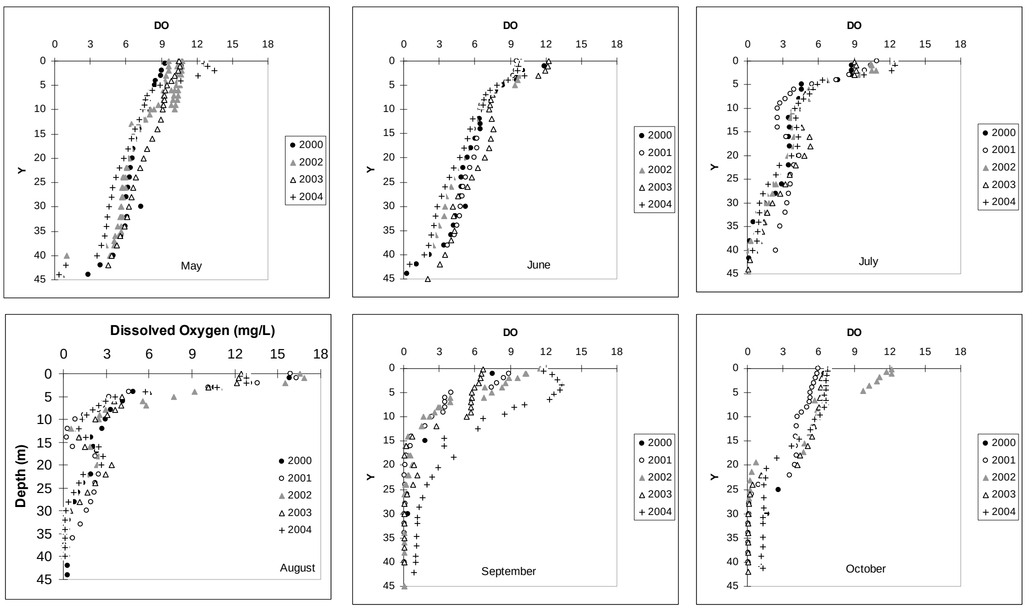


Figure 5.2-4. 2000-2004 Dissolved Oxygen Profiles for Iron Gate Reservoir during May-October.

Table 5.2-4. Summary of Dissolved Oxygen Measurements Taken in Iron Gate Reservoir by Depth Strata and Season from 2005 through 2009.

Season	Depth Strata		
	0-7 m	**7-18 m**	**> 18 m**
Winter			
Count (n)	26	26	59
10th Percentile Value (mg/L)	8.0	8.1	8.2
Mean (mg/L)	10.2	9.8	9.3
Median (mg/L)	10.6	10.1	9.4
90th Percentile Value (mg/L)	11.5	10.5	10.2
Spring			
Count (n)	53	55	107
10th Percentile Value (mg/L)	8.5	6.1	2.1
Mean (mg/L)	10.3	8.8	5.2
Median (mg/L)	10.2	7.7	5.0
90th Percentile Value (mg/L)	11.8	10.8	7.8

Table 5.2-4. Summary of Dissolved Oxygen Measurements Taken in Iron Gate Reservoir by Depth Strata and Season from 2005 through 2009.

Season	Depth Strata		
	0-7 m	**7-18 m**	**> 18 m**
Summer			
Count (n)	70	71	143
10th Percentile Value (mg/L)	5.6	1.6	0.3
Mean (mg/L)	9.3	4.2	1.7
Median (mg/L)	9.0	4.4	1.0
90th Percentile Value (mg/L)	14.1	6.8	3.9
Fall			
Count (n)	28	30	79
10th Percentile Value (mg/L)	6.0	4.2	0.7
Mean (mg/L)	7.3	6.2	2.4
Median (mg/L)	7.2	6.5	1.4
90th Percentile Value (mg/L)	8.5	7.7	5.8

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. During winter, when the reservoir is not stratified, dissolved oxygen throughout the reservoir (in all three depth strata) is relatively high, with mean values exceeding 9.3 mg/L and 90 percent of all values exceeding 8 mg/L (Table 5.2-4). Variation in dissolved oxygen values between strata is most evident in spring and summer seasons when Iron Gate reservoir exhibits seasonal temperature stratification (Figure 5.2-5). In spring, dissolved oxygen concentrations in the surface water (epilimnion) remain high during spring, with a mean value of 10.3 mg/L and 90 percent of all values greater than 8.5 mg/L (Table 5.2-4). One hundred percent of all epilimnetic values during spring exceeded 85 percent saturation (Table 5.2-5). By comparison, waters below 18-m depth have lower oxygen, with a mean value of 5.2 mg/L and 90 percent of all values less than 7.8 mg/L (Table 5.2-4). At the peak of stratification in Iron Gate reservoir during summer, dissolved oxygen concentrations in the surface water (epilimnion) remain high, with a mean value of 9.3 mg/L and 90 percent of all values greater than 5.6 mg/L (Table 5.2-4). About 80 percent of all epilimnetic values during summer exceeded 85 percent saturation (Table 5.2-5). By comparison, waters below 18-m depth have low oxygen, with a mean value of 1.7 mg/L and 90 percent of all values less than 3.9 mg/L (Table 5.2-4). In fall, stratification lessens in intensity but persists until the reservoir again returns to a mixed condition in winter. In fall, the means of dissolved oxygen values were 7.3, 6.2, and 2.4 mg/L in the epilimnion, metalimnion, and hypolimnion, respectively (Table 5.2-4).

Table 5.2-5. Percent of Dissolved Oxygen Values Taken in Iron Gate Reservoir that Equaled or Exceeded 6, 8, or 10 mg/L and 80, 85, and 90 Percent Saturation.

Season	Percent of Values that Equal or Exceed					
	6 mg/L	**8 mg/L**	**10 mg/L**	**80 % Sat**	**85 % Sat**	**90 % Sat**
Winter						
0-7 m depth	100	96	70	73	65	62
7-18 m depth	100	100	73	75	54	38
> 18 m depth	100	97	25	47	17	0
Spring						
0-7 m depth	100	100	30	100	100	97
7-18 m depth	95	49	18	56	45	29
> 18 m depth	34	10	3	7	4	3
Summer						
0-7 m depth	85	67	41	83	80	75
7-18 m depth	20	5	0	13	10	8
> 18 m depth	4	3	0	3	3	3
Fall						
0-7 m depth	95	36	0	36	20	10
7-18 m depth	57	3	0	13	7	0
> 18 m depth	10	0	0	0	0	0

As in Copco reservoir, these dissolved oxygen levels in Iron Gate reservoir provide suitable conditions for fish in the reservoir, since most fish occur in the epilimnion and above the thermocline (Section 5.1.11.2). 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. As such, the epilimnetic mean values (i.e., related to the 0-7 m depth strata) tend to represent the discharge concentrations of dissolved oxygen from Iron Gate reservoir (as discussed further in the following section below).

Hornbrook Hydrologic Subarea

Dissolved oxygen data has been collected by continuously-recording datasonde in the Klamath River below Iron Gate dam (RM 190) since 2008. This data is posted under the tab "Water Quality Reports & Data" at PacifiCorp's website at http://www.pacificorp.com/es/hydro/hl/kr.html#. Additional dissolved oxygen data also were previously 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 (PacifiCorp 2004h, PacifiCorp 2008b). Additional measurements were made approximately bi-weekly between June and November from 2007 through 2009 (Raymond 2008a, Raymond 2009a, Raymond 2010a).

Dissolved oxygen levels in the Klamath River below Iron Gate dam varies seasonally as represented in the two most recent years (2012 and 2013) of complete datasonde measurements (Figure 5.2-5). Dissolved oxygen levels are near full saturation (at or above 90 percent) at concentrations of 8 mg/L to 10 mg/L during winter, spring, and early summer. From mid-summer through mid-fall, the dissolved oxygen levels in the releases to the river from Iron Gate reservoir are typically more variable, ranging both above and below saturation, with minimum values in late September to early October (Figure 5.2-5). The more variable and lower dissolved oxygen conditions in the August-October period reflect: (1) the production and respiration effects from algae blooms at this time; and (2) the increase in subsaturated conditions that occur in deeper waters of Iron Gate reservoir during this period that can at times be entrained into the powerhouse intake.

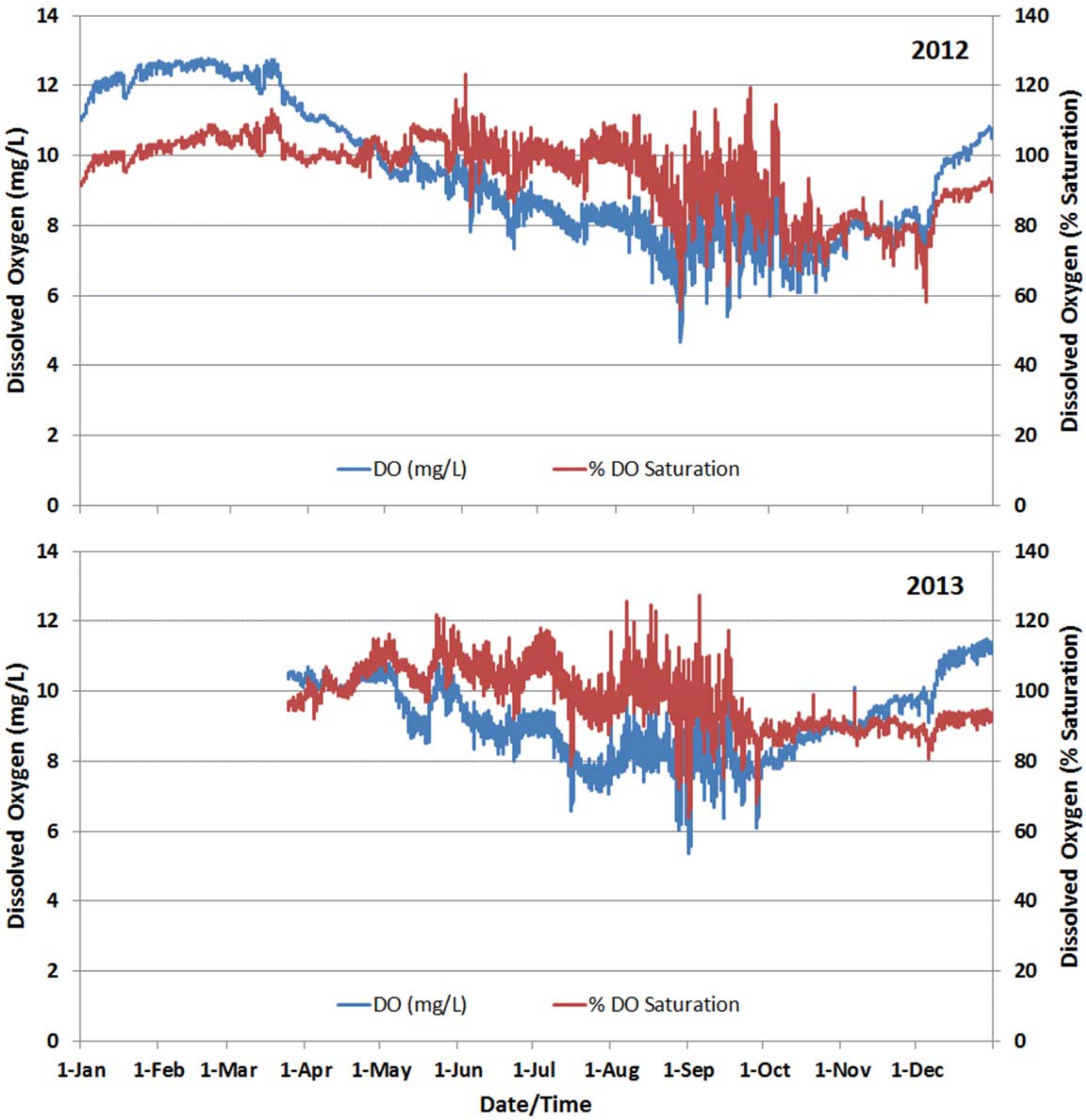


Figure 5.2-5. Dissolved oxygen (in mg/L and % saturation) measured during 2012 (top) and 2013 (bottom) by continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

During winter, dissolved oxygen levels in the Klamath River below Iron Gate dam remain relatively high. Values during winter in 2012 and 2013 exceeded 10 mg/L and 90 percent saturation over 90 percent of the time during continuous recording downstream of Iron Gate dam (Figures 5.2-6 and 5.2-7). During spring, dissolved oxygen levels also remain relatively high. Values during spring in 2012 and 2013 exceeded 9 mg/L and 90 percent saturation over 95 percent of the time during continuous recording downstream of Iron Gate dam (Figures 5.2-6 and 5.2-7).

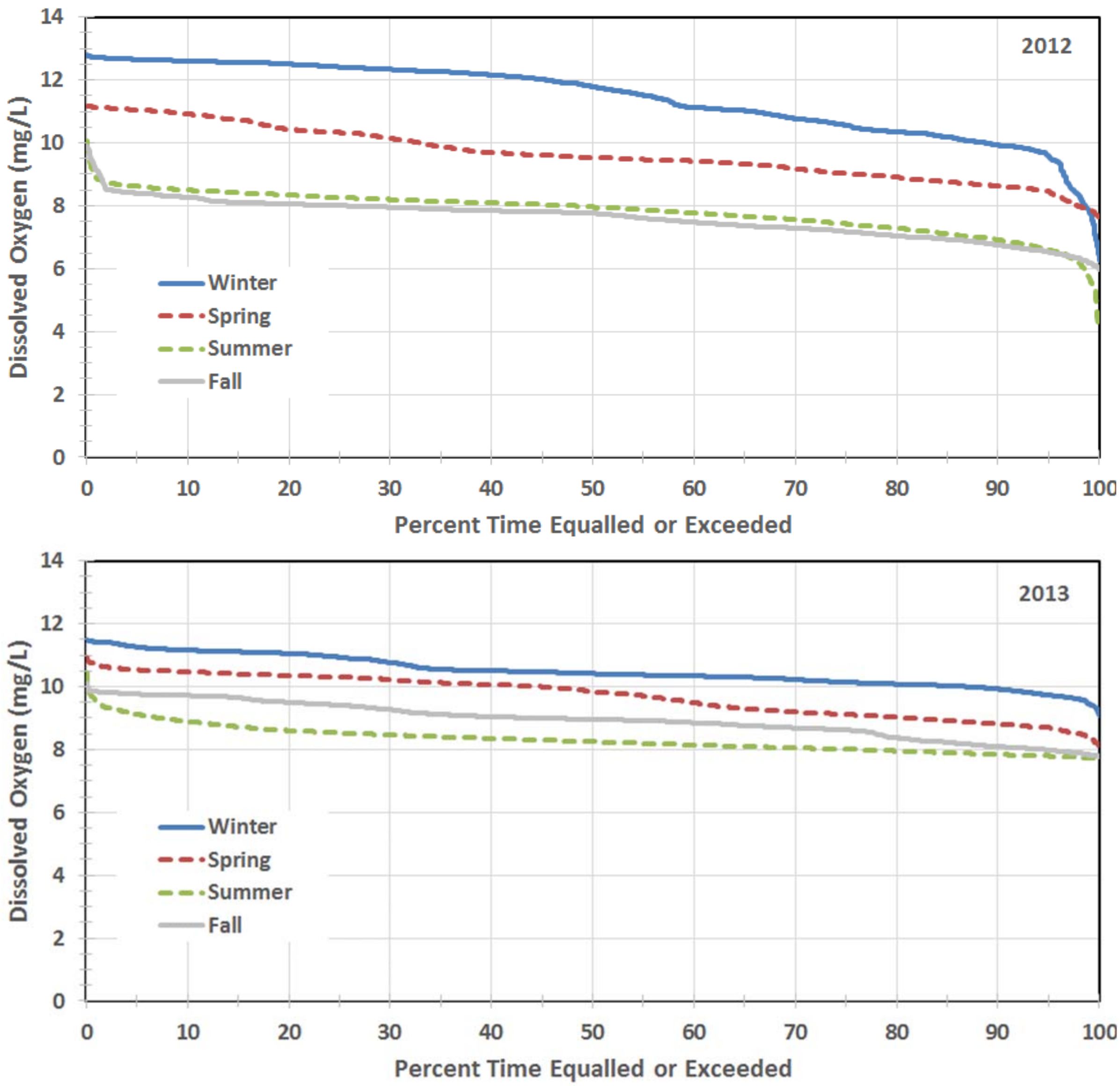


Figure 5.2-6. Percent exceedance curves for dissolved oxygen (in mg/L) measured during 2012 (top) and 2013 (bottom) by continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

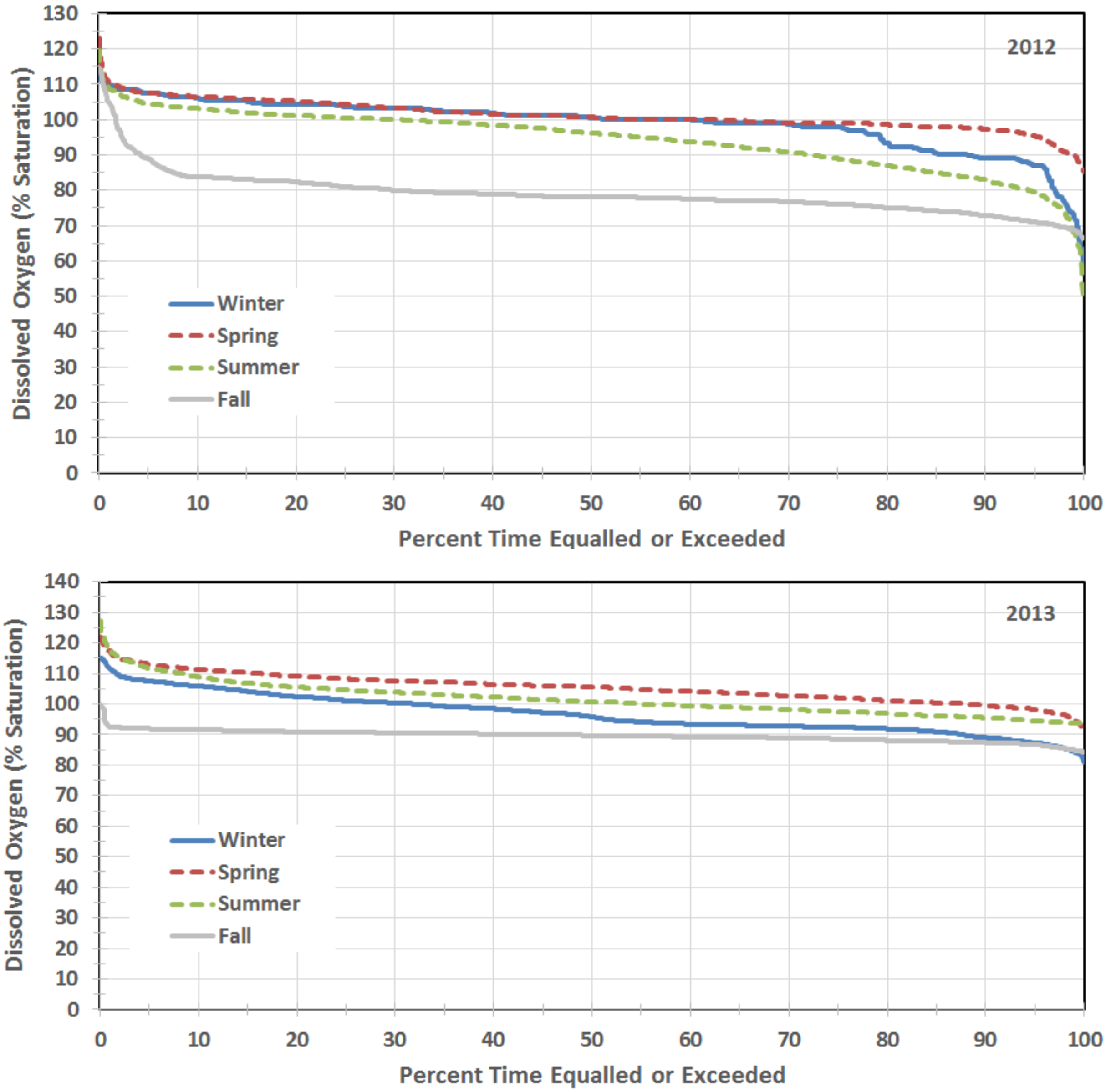


Figure 5.2-7. Percent exceedance curves for dissolved oxygen (in % saturation) measured during 2012 (top) and 2013 (bottom) by continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

During summer and fall, dissolved oxygen levels in the Klamath River below Iron Gate dam are generally lower and more variable than in winter and spring. However, summer and fall conditions in 2013 were notably higher than in 2012, which indicates that turbine venting provides appreciable dissolved oxygen enhancement in powerhouse releases as was originally predicted by Mobley (2005). During summer, dissolved oxygen values exceeded 7 mg/L and 85 percent saturation over 90 percent of the time in 2012, but then exceeded 8 mg/L and 95 percent saturation over 90 percent of the time in 2013 (Figures 5.2-7 and 5.2-8). During fall, dissolved oxygen values exceeded 7 mg/L and 75 percent saturation over 90 percent of the time in 2012, but then exceeded 8 mg/L and 90 percent saturation over 90 percent of the time in 2013 (Figures 5.2-6 and 5.2-7).

As described in Section 4.2.10 above, dissolved oxygen levels further downstream in the lower 190-mile Klamath River reach generally vary from approximately 7.0 to 12.0 mg/L during the year (for example, see Figure 4.2-26 in Section 4.2.10). The annual trends and ranges in dissolved oxygen concentrations are generally consistent as waters travel downriver due to the many cascades, rapids, and riffles present in the river that provide mechanical reaeration. Dissolved oxygen is persistently and mildly sub-saturated (generally less than 100 percent) throughout the 190-mile Klamath River reach (NCRWQCB 2010). NCRWQCB (2010) conducted a river-wide assessment of DO saturation and determined that full saturation (100 percent) in the Klamath River in California is not achievable under natural conditions in the basin. As a result of this assessment, site-specific dissolved oxygen objectives for the Klamath River in California are established that vary from 85 to 90 percent saturation depending on season and location (sub-reaches) along the lower 190-mile Klamath River reach as described above in Section 5.2.1.1.

5.2.1.3 Project Contribution

Klamath River from Stateline to Copco Reservoir

Dissolved oxygen conditions in the Klamath River from Stateline to Copco reservoir are not detrimentally affected by the Project. 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 Upper Klamath Lake. As described in Section 5.2.1.2 above, dissolved oxygen measurements obtained in recent years in the Klamath River upstream of Copco reservoir near Shovel Creek (RM 206.4) indicate that dissolved oxygen levels consistently exceed 8.0 mg/L and 90 percent saturation (Figure 5.2-1).

Copco Reservoir and Iron Gate Hydrologic Subareas

As described in Section 5.2.1.2 above, dissolved oxygen conditions in Copco and Iron Gate vary seasonally and by depth strata in the reservoirs. During winter, when the reservoirs are not stratified, dissolved oxygen concentrations throughout the reservoirs are relatively high. Winter mean values exceed 10.4 mg/L in Copco reservoir (Table 5.2-2) and 9.3 mg/L in Iron Gate reservoir (Table 5.2-4). Even though dissolved oxygen concentrations are relatively high, the percent-saturation of dissolved oxygen in the reservoirs in winter does not consistently meet the Basin Plan's specific dissolved oxygen objective of 90 percent-saturation that applies during winter (as described in Section 5.2.1.1 above). Winter median values are about 90 percent-saturation in Copco reservoir and 82 percent-saturation in Iron Gate reservoir. Of all winter dissolved oxygen measurements obtained in the reservoirs, 90 percent of the values exceeded levels of about 75 percent-saturation in Copco reservoir and 63 percent-saturation in Iron Gate reservoir. Although the Basin Plan's specific dissolved oxygen of 90 percent is not consistently met, the relatively high dissolved oxygen concentrations during winter in both reservoirs provide suitable conditions for fish.

During spring and summer, dissolved oxygen conditions in the surface layers (epilimnion) of Copco and Iron Gate remain relatively high. In spring, the mean of dissolved oxygen values in the epilimnions of Copco and Iron Gate reservoirs were 9.8 and 10.3 mg/L, respectively, with 100 percent of the epilimnetic values in both reservoirs exceeding 85 percent saturation (Table 5.2-3). In summer, the mean of dissolved oxygen values in the epilimnions of Copco and Iron Gate reservoirs were 9.7 and 9.3 mg/L, respectively, with 96 percent and 80 percent of epilimnetic values in Copco and Iron Gate reservoirs, respectively, exceeding the 85 percent saturation. As such, the Basin Plan's specific dissolved oxygen objective of 85 percent that applies during spring and summer is always or mostly met in the epilimnions of both Copco and Iron Gate reservoirs. In addition, the relatively high dissolved oxygen concentrations during spring and summer in the epilimnions of both reservoirs continues to provide suitable conditions for fish.

By comparison, dissolved oxygen conditions are lower in the metalimnion and hypolimnion of Copco and Iron Gate reservoirs during spring and summer due to the effects of seasonal stratification. As described in Section 5.2.1.2 above, stratification of the reservoirs acts to impede mixing of bottom waters with surface waters in the reservoirs. As a consequence, decomposition of organic carried into the reservoirs from the Klamath River, and settling from shallow depths from within the reservoirs, results in lowering of dissolved oxygen in the metalimnion and hypolimnion. As a consequence, the Basin Plan's specific dissolved oxygen objective of 85 percent is inconsistently or infrequently met in these deeper layers of both reservoirs.

In fall, thermal stratification diminishes until the reservoir again returns to a mixed condition heading into winter. The mixing in the reservoirs (in combination with a reduction in primary production) creates conditions whereby dissolved oxygen becomes slightly lower in the surface layers of the reservoirs and slightly higher in the deeper portions of the reservoirs. In fall, the mean of dissolved oxygen values in the epilimnions of Copco and Iron Gate reservoirs were 8.6 and 7.3 mg/L, respectively. About 39 percent and 10 percent of epilimnetic values, respectively, in Copco and Iron Gate reservoirs met the Basin Plan's specific dissolved oxygen objective of 90 percent-saturation that applies during fall. The mean of fall dissolved oxygen values in the metalimnions of Copco and Iron Gate reservoirs were 7.9 and 6.2 mg/L, respectively, with 25 percent and none of metalimnetic values, respectively, in the reservoirs meeting the objective of 90 percent-saturation.

<u>Hornbrook Hydrologic Subarea</u>

As discussed in Section 5.2.1.2 above, dissolved oxygen levels in the Klamath River below Iron Gate dam are near saturation (at or above 90 percent) at concentrations of 8 mg/L to 10 mg/L during winter, spring, and early summer. For the most part, dissolved oxygen levels in the Klamath River below Iron Gate dam reflect conditions in the surface layer (epilimnion) of Iron Gate reservoir. The position of the power intake allows entrainment of mostly water from the surface layer (epilimnion) of Iron Gate reservoir to be discharged through the powerhouse to the river.

Recent datasonde measurements indicate that median dissolved oxygen levels in the Klamath River below Iron Gate dam exceed 10 mg/L in winter and spring and 8 mg/L during summer and fall (Figure 5.2-7). During winter, the Basin Plan's specific dissolved oxygen objective of 90 percent-saturation is met about 90 percent of the time during winter (Figure 5.2-8). During spring, the Basin Plan's specific dissolved oxygen objective of 85 percent-saturation is met nearly 100 percent of the time during spring. During summer, the Basin Plan's specific dissolved oxygen objective of 85 percent-saturation is met over 85 percent of the time during summer. During fall, the Basin Plan's specific dissolved oxygen objective of 90 percent-saturation is met over 75 percent of the time during fall (Figure 5.2-8).

As discussed in Section 5.2.1.2 above, summer and fall conditions in 2013 were notably higher than in 2012, which indicates that turbine venting provides appreciable dissolved oxygen enhancement in powerhouse releases. For example, dissolved oxygen values improved from 75 percent saturation over 90 percent in fall 2012 to 90 percent saturation over 90 percent in fall 2013 (Figure 5.2-8).

5.2.1.4 Proposed Measures

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

No activity or facility of the Project adversely influences dissolved oxygen in this segment of the river. Dissolved oxygen values reflect naturally occurring conditions. 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 effect of improving dissolved oxygen conditions in Copco reservoir.

The RMP (Appendix B) is a revised version of a similar plan developed in March 2008 (PacifiCorp 2008b). 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, 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.

The RMP (Appendix B) describes the specific planned activities and actions by PacifiCorp for further evaluation, design, and implementation of techniques for water quality improvements in Copco reservoir. Several of these actions address development of potential measures to further enhance dissolved oxygen conditions in the reservoir, including: (1) design and implementation planning of reservoir oxygenation systems; (2) evaluation of epilimnion (surface water) mixing and circulation; (3) further evaluation of selective withdrawal and intake control; and (4) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoir. In addition, the RMP includes action to assess potential design and implementation of constructed wetlands. Given that water quality conditions in Copco reservoir, including dissolved oxygen, are largely driven by the large nutrient and organic loads from upstream sources (particularly Upper Klamath Lake), 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. The RMP (Appendix B), as described above for Copco reservoir, also includes potential measures to further enhance dissolved oxygen conditions in the Iron Gate reservoir, including: (1) constructed wetlands conceptual design and implementation planning; (2) further evaluation of tailrace aeration and oxygenation systems; (3) design and implementation planning of reservoir oxygenation systems; (4) evaluation of epilimnion (surface water) mixing and circulation; (5) further evaluation of selective withdrawal and intake control; and (6) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoir.

Hornbrook Hydrologic Subarea

As discussed in Section 5.2.1.3 above, the Basin Plan's specific dissolved oxygen objective is met much of the time in the Klamath River downstream of Iron Gate dam. In addition, recent monitoring indicates that turbine venting at the Iron Gate powerhouse provides appreciable dissolved oxygen enhancement in powerhouse releases. PacifiCorp plans to continue with further monitoring of turbine venting operations to verify air flow and dissolved oxygen increases, and to make adjustments (if needed), as described in the RMP (Appendix B). To date, monitoring indicates that turbine venting appreciably enhances tailrace dissolved oxygen levels. However, if additional tailrace dissolved oxygen augmentation is needed, PacifiCorp will proceed to conduct additional evaluations of potential tailrace oxygenation (using hypolimnetic diffuser or side-stream oxygenation) as described in the RMP (Appendix B).

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, meteorology, water chemistry, and primary production 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 and rocks, the weathering of which can contribute to increased alkalinity. Higher alkalinity tends to resist changes to pH, termed strongly buffered. While 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 decrease in response to respiratory, fermentation, and other non-photosynthetic 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 Upper Klamath Lake, 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 5.2-8). 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. Mechanical reaeration can introduce CO_2 into the river, reducing elevated pH values resulting from primary production.

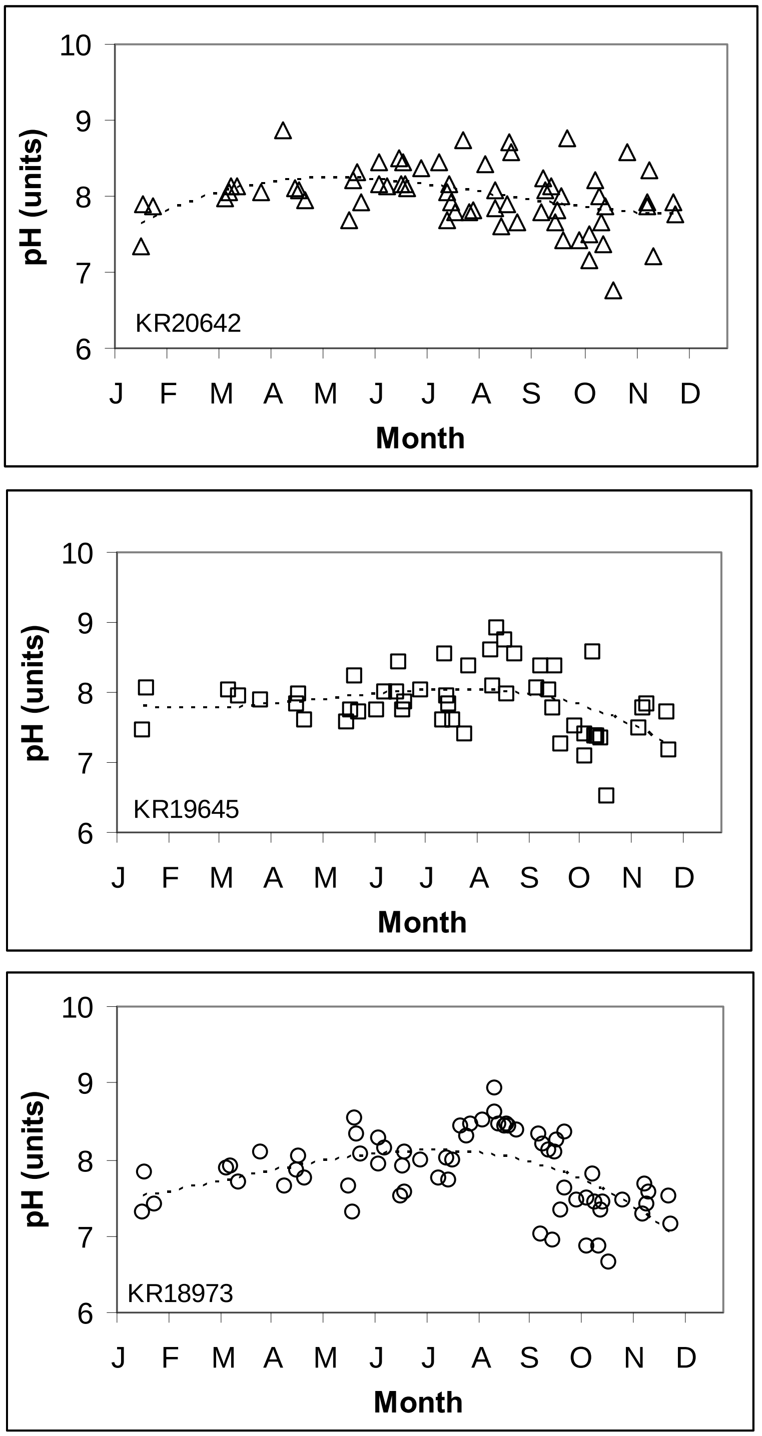


Figure 5.2-8. Seasonal variation in pH values measured in the Klamath River above Copco reservoir near Shovel Creek (KR20642), below Copco 2 powerhouse (KR19645), and below Iron Gate dam (KR18973).

Measurements for pH have been made approximately monthly between March and November from 2000 through 2005, and June through November from 2007 through 2009 at a number of sites in the relevant segments of the Klamath River (PacifiCorp 2004h, PacifiCorp 2008b, Raymond 2008a, Raymond 2009a, Raymond 2010a). These sites are identified in Table 5.2-6. Vertical profile measurements of pH have been made in Copco and Iron Gate reservoirs on the same schedule. As shown in Table 5.2-7, 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 5.2-6. 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 5.2-7. 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

Klamath River from Stateline to Copco Reservoir

Measurements of pH were made in this river segment at RM 206 (KR20642) near Shovel Creek. Descriptive statistics are shown in Table 5.2-7. A summary of the measurements with respect to the water quality objectives is provided in Table 5.2-8. 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 5.2-8. The distribution of pH values reflects the algal response to inputs 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 5.2-8. The distribution of pH values reflects the algal response to inputs 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.

Table 5.2-8 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	12.8
Iron Gate Reservoir < 8 m	485	25	19.6	8	1.6
Iron Gate Reservoir > 20 m	613	0	0.0	135	22.0

Hornbrook Hydrologic Subarea

Measurements of pH have been collected by continuously-recording datasonde in the Klamath River below Iron Gate dam (RM 190) since 2008. This data is posted under the tab “Water Quality Reports & Data” at PacifiCorp’s website at http://www.pacificorp.com/es/hydro/hl/kr.html#. Additional pH data also were previously 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 (PacifiCorp 2004h, PacifiCorp 2008b). Additional measurements were made approximately bi-weekly between June and November from 2007 through 2009 (Raymond 2008a, Raymond 2009a, Raymond 2010a).

Levels of pH in the Klamath River below Iron Gate dam varies seasonally as represented in recent datasonde measurements from 2012 (Figure 5.2-9). Levels of pH range from about 7 to 9 (with a median of about 8), with higher and more variable levels generally occurring during spring and summer concurrent with higher algal production in the Klamath River system.

As described above in Section 4.2.10, pH generally ranges from 7 to 9 and alkalinity is generally under 100 mg/L throughout the lower 190-mile Klamath River reach (PacifiCorp 2004e, PacifiCorp 2008b). 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 the range of 8.5 to over 9.0 in the early afternoon during late spring and summer periods in the reach between Iron Gate dam and Seiad Valley (see Figure 4.2-26 in Section 4.2.10).

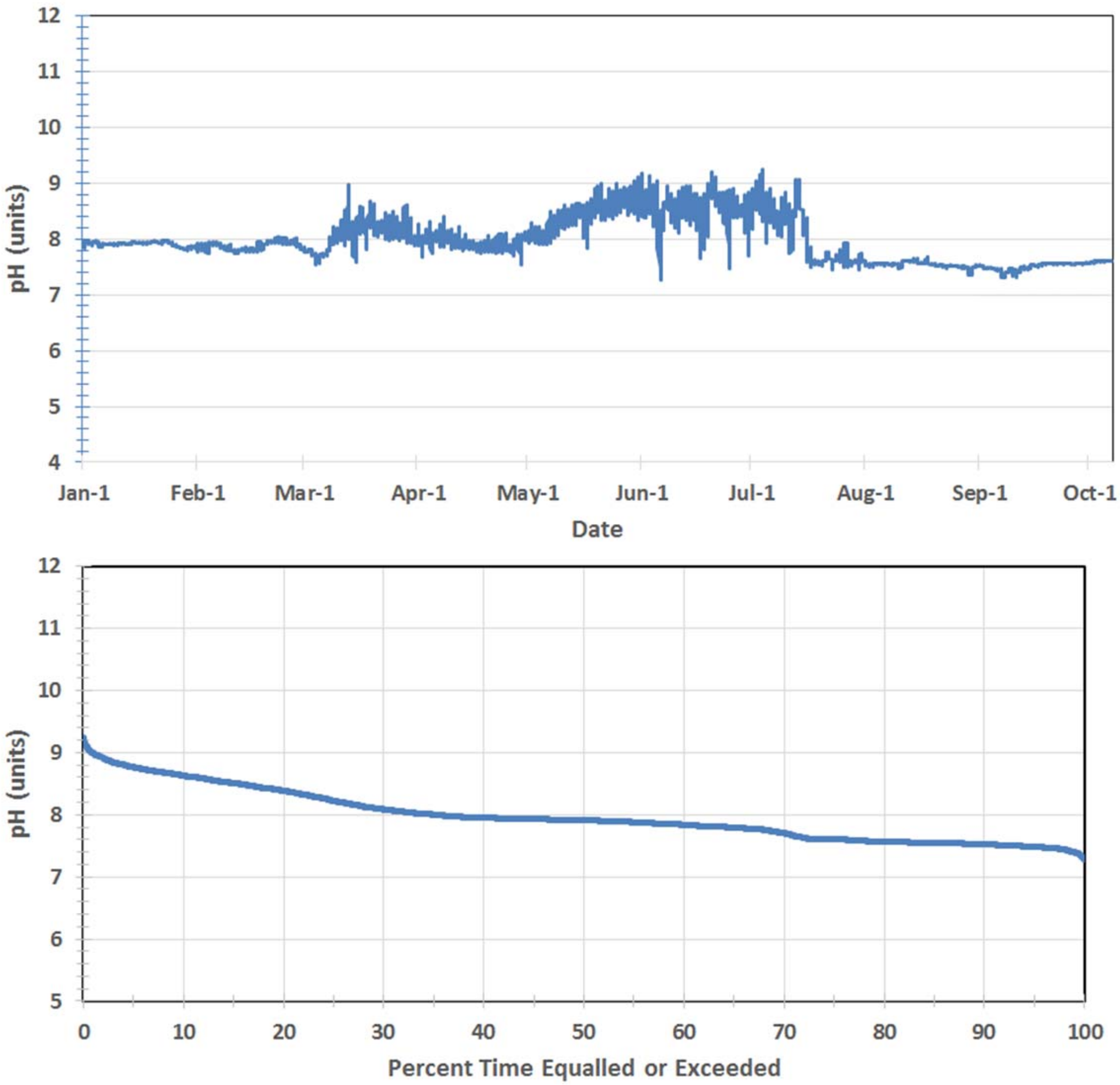


Figure 5.2-9. Time-series of pH (top plot) and percent exceedance curves for pH (bottom plot) measured during 2012 by continuously-recording datasonde in the Klamath River below Iron Gate reservoir (RM 190).

5.2.2.3 Project Contribution

Klamath River from Stateline to Copco Reservoir

The summary of pH values listed Table 5.2-8 indicates that pH values measured in the Klamath River above Copco reservoir (near Shovel Creek) met the Basin Plan's specific pH objective of 7 to 8.5 most (about 89 percent) of the time. Primary production in this segment of the river is in response to nutrients from upstream of the Project, primarily from Upper Klamath Lake. 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 Project and no substances are released that could modify pH.

Copco Reservoir Hydrologic Subarea and Iron Gate Hydrologic Subarea

The summary of pH values listed Table 5.2-8 indicates that pH values measured in Copco reservoir met the Basin Plan's specific pH objective of 7 to 8.5 about 80 percent of the time. The pH values in the epilimnion of Copco reservoir met the pH objective about 70 percent of the time. The summary in Table 5.2-8 indicates that pH values measured in Iron Gate reservoir met the pH objective of 7 to 8. about 80 percent of the time, and that the pH values in the epilimnion of Iron Gate reservoir also met the pH objective about 80 percent of the time.

Photosynthetic activity in the epilimnion of Copco and Iron Gate reservoirs leads to a higher pH and larger diurnal range of pH values in the epilimnion at times during the year when the reservoirs are stratified. Algal respiration in the hypolimnion leads to lower pH during the same periods (Figure 5.2-10). The higher rate of photosynthesis is attributed to the high levels of nutrients from upstream of the Project. There are no nutrients contributed by the Project and no substances are released that could modify pH.

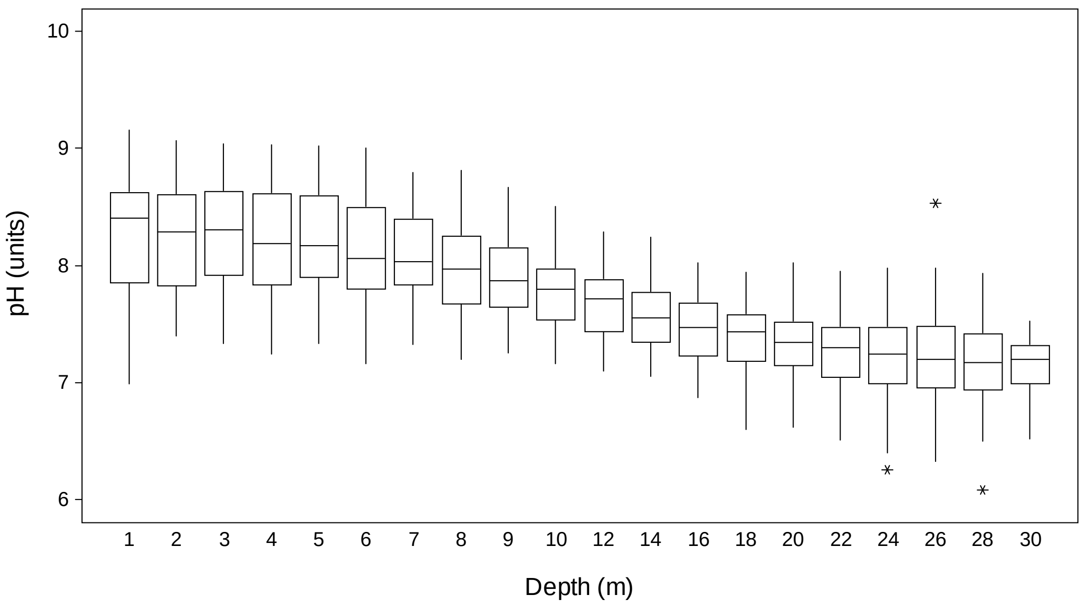


Figure 5.2-10. Distribution of pH Values Measured at Different Depths in Copco Reservoir during 2000 through 2005.

Hornbrook Hydrologic Subarea

Because water is released from Iron Gate reservoir from a point approximately 10 m below the surface, the released water is similar in range to the mean of pH found in the surface layer (epilimnion) of Iron Gate reservoir. Similar to the epilimnion of Iron Gate reservoir, the datasonde measurements of pH in the Klamath River below Iron Gate dam indicates that the pH objective of 7 to 8.5 was met about 80 percent of the time (Figure 5.2-9).

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.

The pH levels within the Klamath River are typically within the range considered to be suitable for salmonids. However, maximum pH conditions naturally occur that can occasionally exceed 9.0, the recommended range for salmonids and other freshwater aquatic species. When this occasionally occurs, it is a result of the low buffering capacity of the Klamath River, in combination with high photosynthetic activity by phytoplankton, benthic algae, and other aquatic plants. The most effective means to address this level of elevated pH within the Klamath River, although at a relatively low frequency of occurrence, is a reduction in nutrient loading and associated phytoplankton production in the basin.

5.2.2.4 Proposed Measures

The excursions of pH beyond the pH objective of 7 to 8.5 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 Upper Klamath Lake. 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, Asarian et al. 2009). 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 the RMP (Appendix B) for improving reservoir water quality in Copco and Iron Gate reservoirs and the Klamath River downstream of Iron Gate dam. 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 inflow loads of nutrients and organic matter from upstream sources is most appropriately addressed through controls on those sources, primarily upstream in Oregon, for example through the implementation of appropriate Total Maximum Daily Loads (TMDLs) 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.

Actions to be implemented through the RMP (Appendix B) are aimed at improving reservoir water quality conditions notwithstanding the upstream loads of nutrients and organic matter that PacifiCorp cannot control. The RMP will also help to improve water quality in the Klamath River below the Project reservoirs. Therefore, the measures implemented under this RMP complement the system-wide TMDLs by improving water quality until nutrient load reductions can be realized through implementation of appropriate TMDLs.

5.2.3 Temperature

5.2.3.1 Applicable Criteria

The applicable water temperature objective in the North Coast Basin Plan, at 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 5.2-11 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 5.2-11 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 minimal 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. 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 225-250 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 5.2-11).

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

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

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 5.2-12). 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.

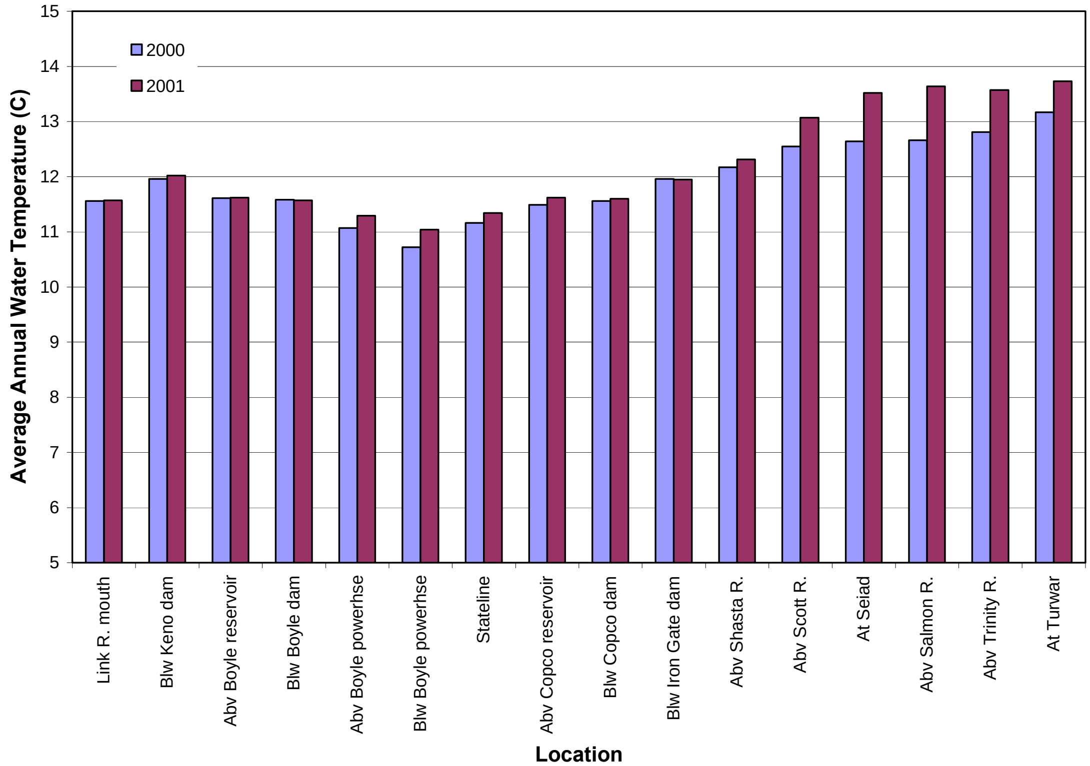


Figure 5.2-11. Histograms of Average Annual Water Temperature (in degrees C, calculated over the entire set of hourly values for the year 2000 and 2001 as examples) in the Klamath River at Locations from the Mouth of Link River (RM 252.7) to Turwar (RM 5.3).

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, effects 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 5.2-13). 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.

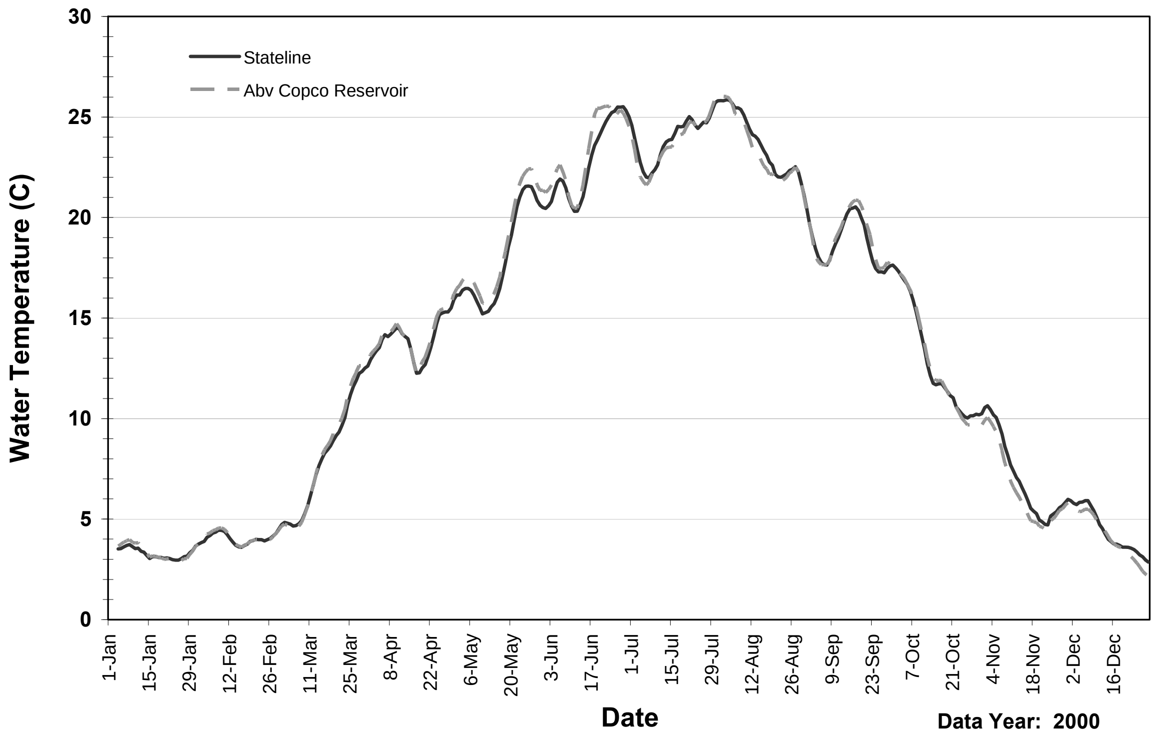


Figure 5.2-12. Annual time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River at Stateline and just above Copco Reservoir under Existing Conditions for 2000.

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 5.2-14 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 multiple nodes in the signal reflect the hydrodynamics of peaking hydropower operations imposed on the constant, relatively cool outflows from the bypass reach. 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.

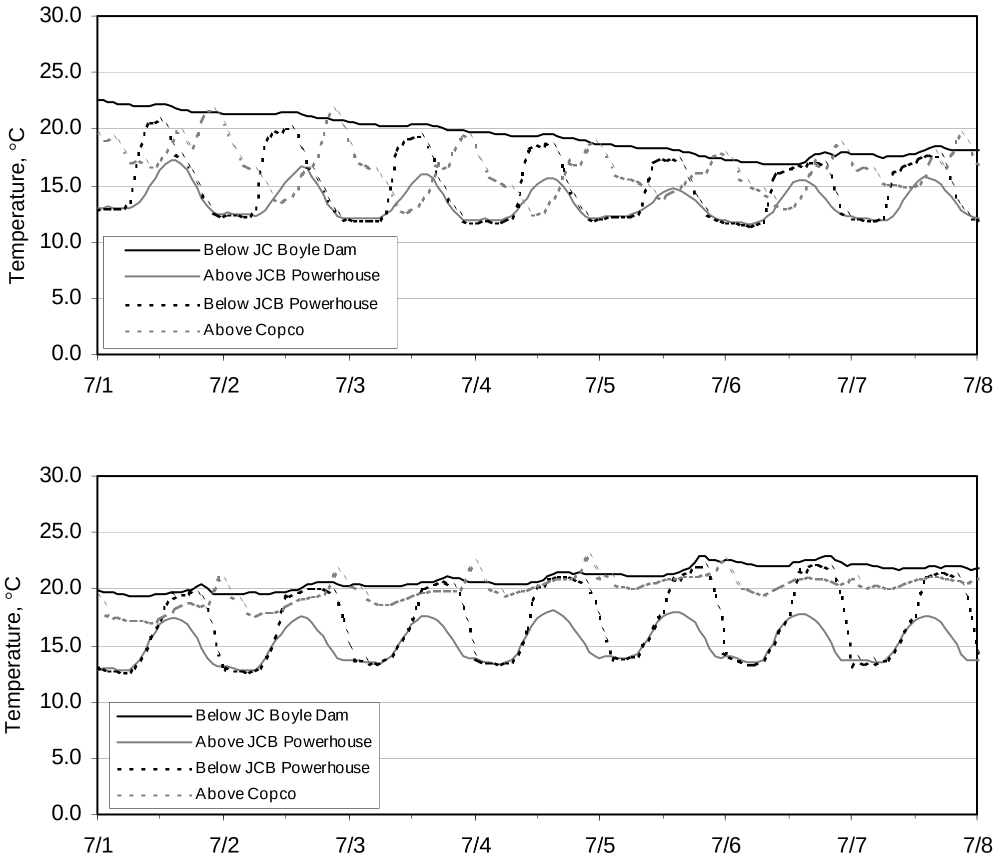


Figure 5.2-13. J.C. Boyle Bypass and Peaking Reach Water Temperatures under Existing Conditions during an Example Period of Typical Summertime Peaking in July 2000 (top) and 2001 (bottom).

Copco and Iron Gate Reservoirs

Copco reservoir undergoes annual thermal stratification. Copco reservoir stratification commences 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 5.2-15. Maximum difference between epilimnetic and hypolimnetic temperatures is about 10°C.

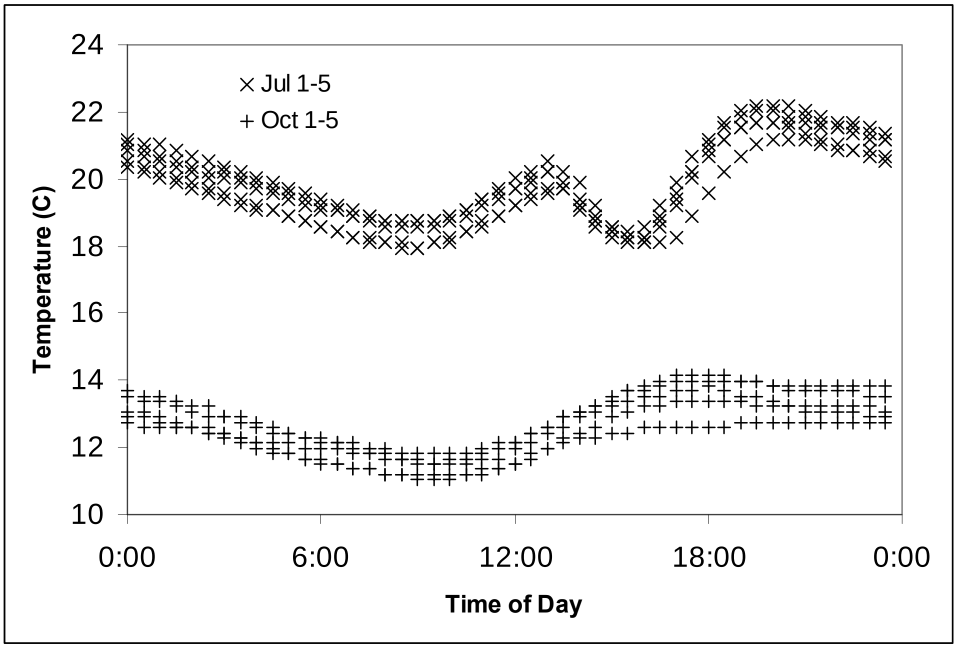


Figure 5.2-14. Water Temperatures Measured in the Klamath River above Shovel Creek (KR20645) during Periods of Peaking Operation (July, top) and during Nonpeaking Discharge (October, bottom) in 2002.

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, with notably smaller volume.

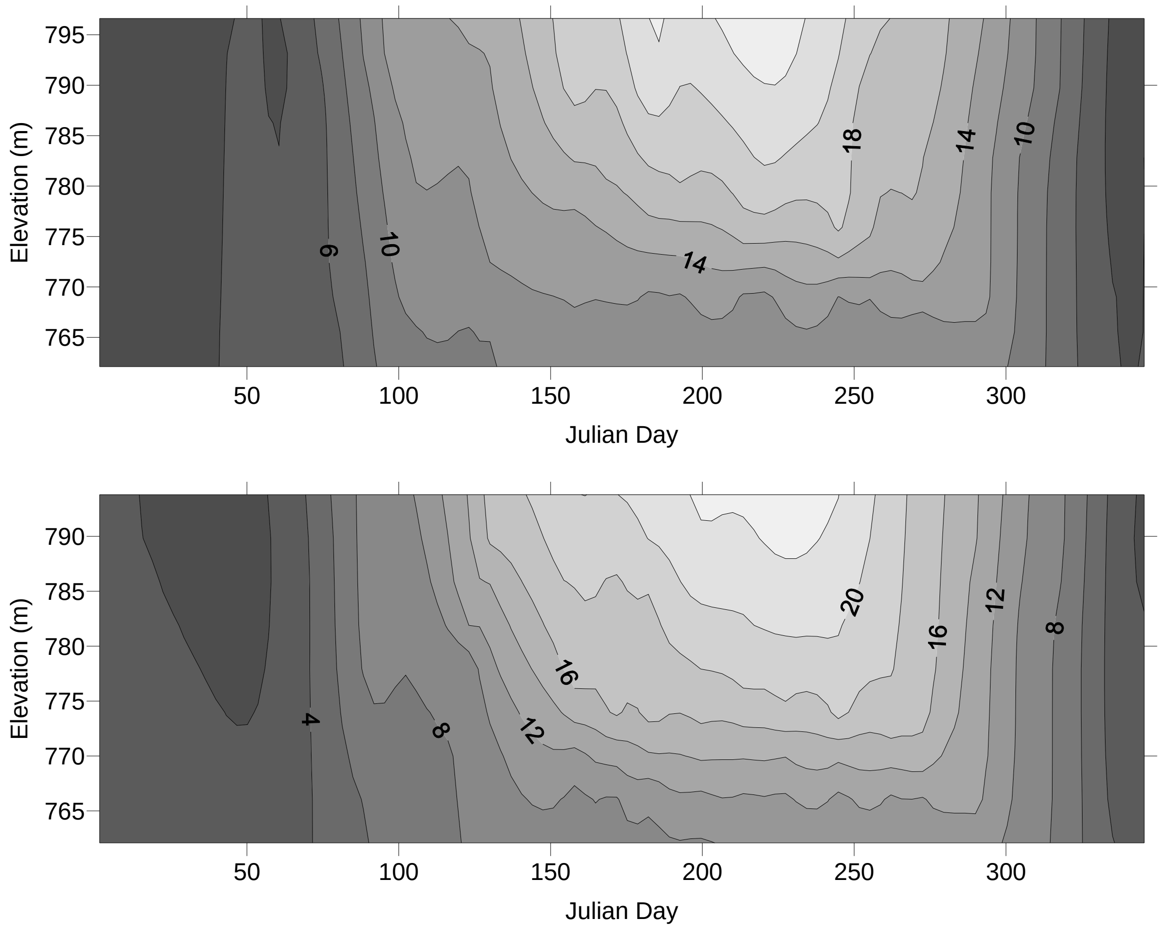


Figure 5.2-15. Copco Reservoir Temperature (°C) Isopleths under Existing Conditions for 2000 (top) and 2001 (bottom).

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 5.2-16. 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).

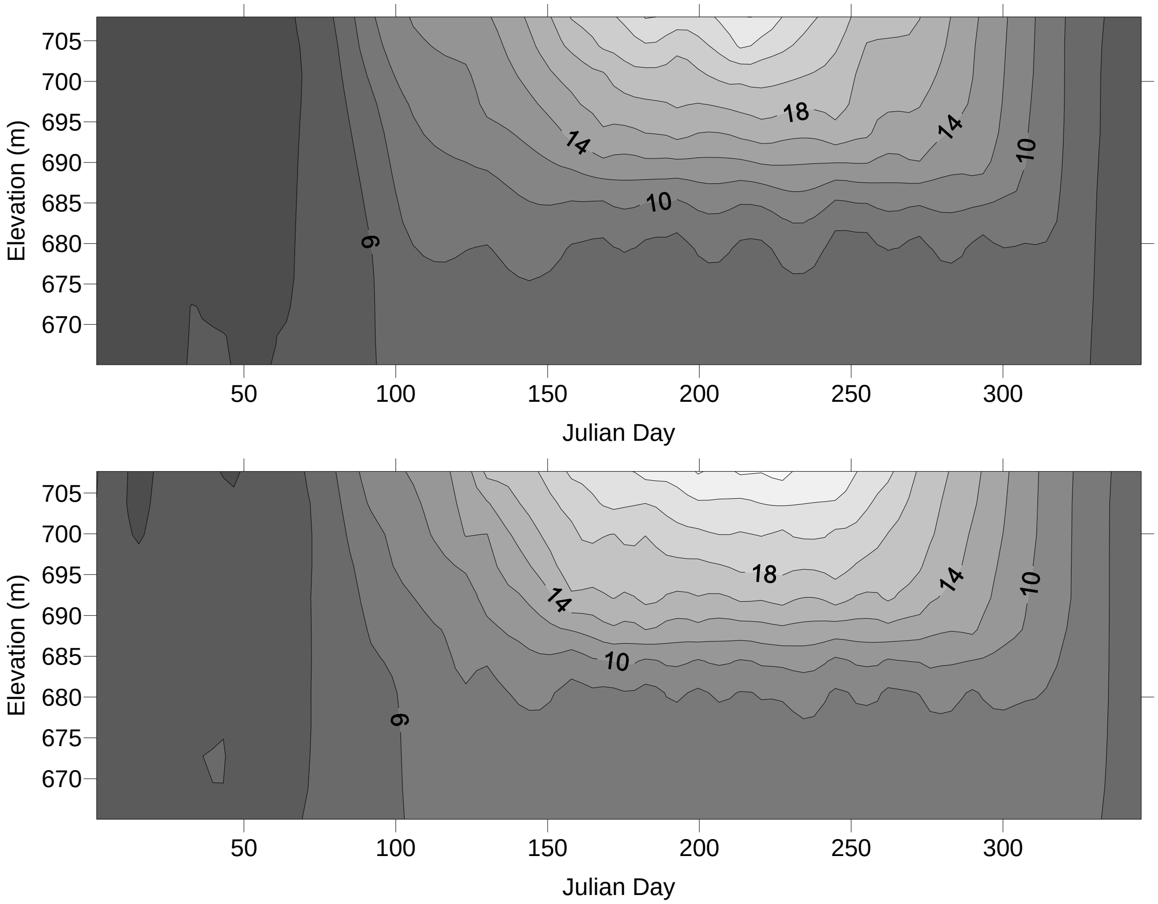


Figure 5.2-16. Iron Gate Reservoir Temperature (°C) Isopleths: EC for 2000 (top) and 2001 (bottom).

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 5.2-17). 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 5.2-17).

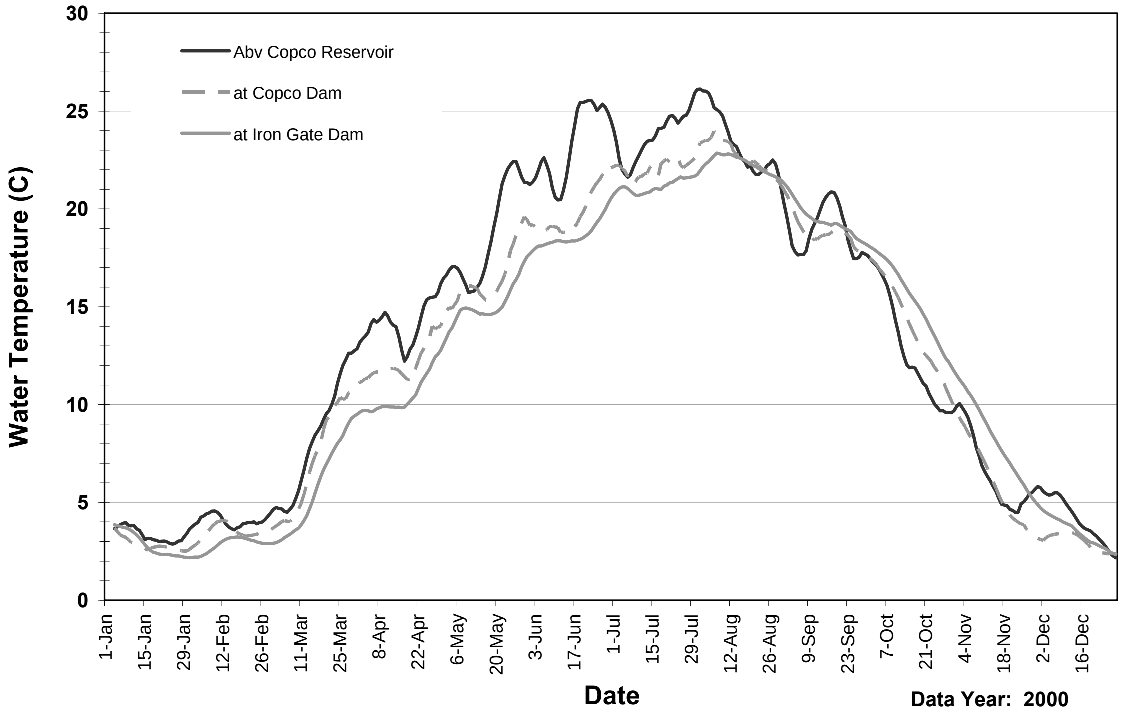


Figure 5.2-17. Annual Time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River just above Copco Reservoir, at Copco No. 1 dam, and at Iron Gate dam under Existing Conditions for 2000.

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 5.2-18), based on the 7-day average of the maximum daily temperatures (7DAD Max). Continuing downstream, the annual maximum water temperatures are generally similar at Seiad Valley (RM 129) and at the Salmon River (RM 67) (Figure 5.2-18), 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 minimum daily 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 further. 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 the Pacific Ocean at the lower elevations (for example, see the January-February period in Figure 5.2-18). The major tributaries generally enter the Klamath River at similar temperatures to the river that are also close to equilibrium. The exception is during spring snowmelt periods when high flows from snowmelt runoff may reach the river below equilibrium temperature.

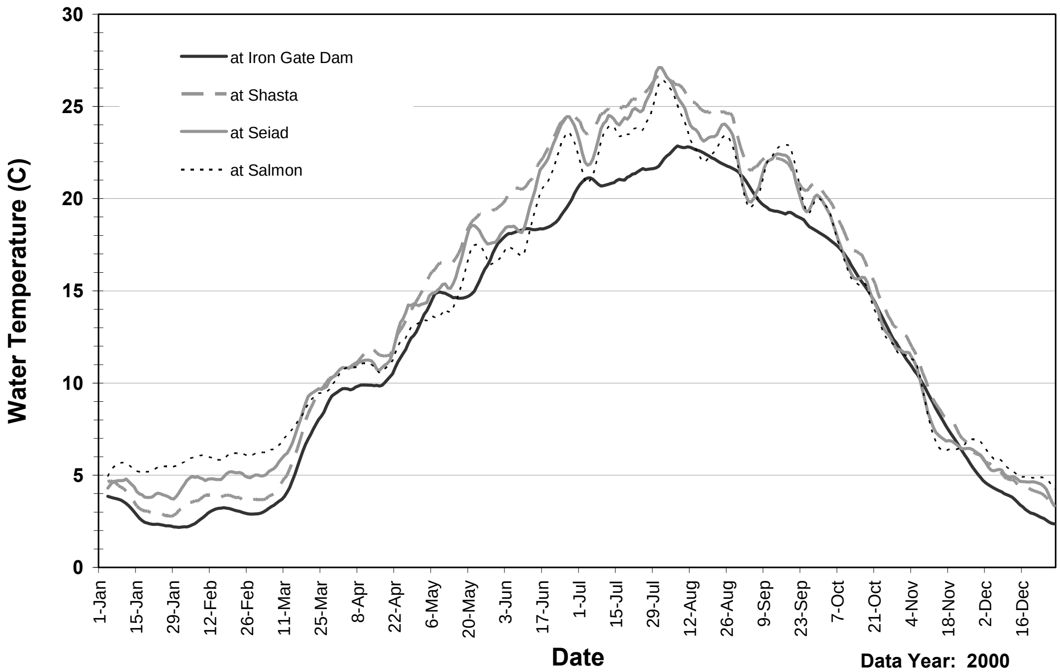


Figure 5.2-18. Annual Time-series of Water Temperature (in degrees C, based on the 7-day average of maximum daily water temperature) in the Klamath River at Iron Gate dam (RM 109.5), just above the Shasta River (RM177.5), at Seiad Valley (RM 129.0), and just above the Salmon River (RM 66.9) under Existing Conditions for 2000.

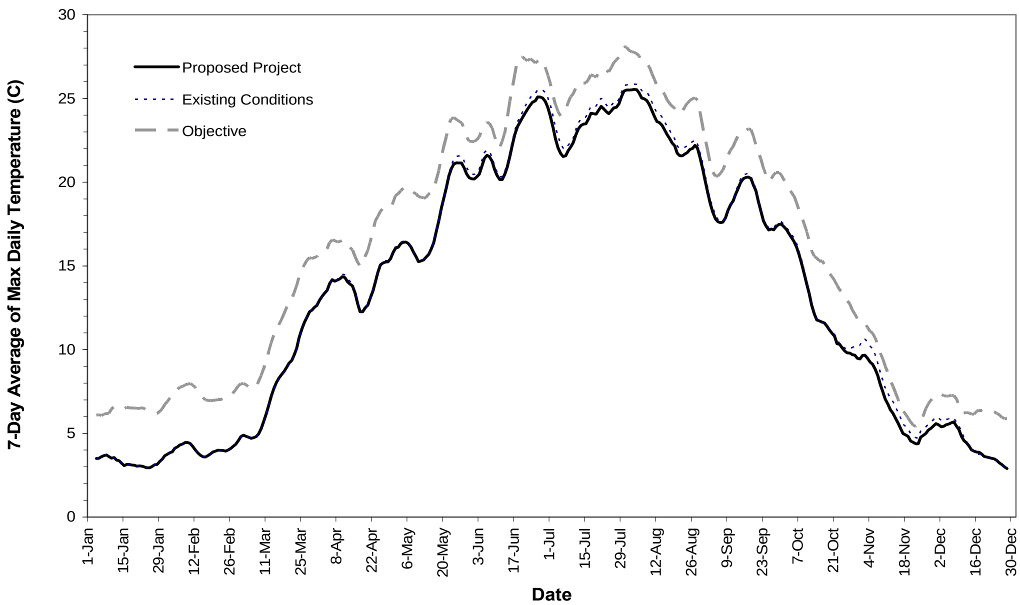
5.2.3.3 Project Contribution

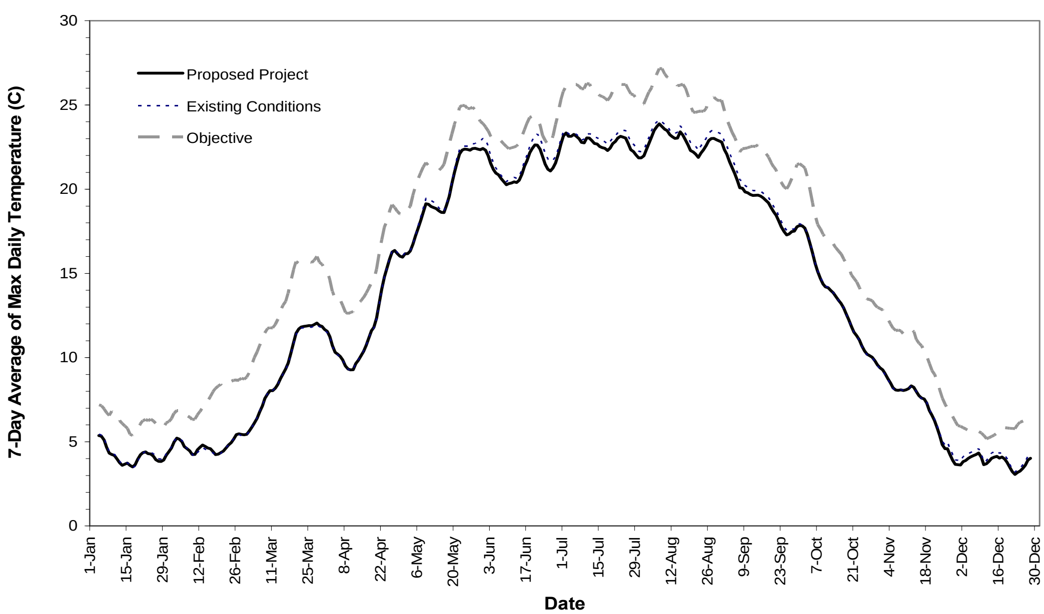
The extent to which the Project contributes to current water temperature conditions in the Project reaches in California are described below. These effects are described based on field observations and supported by water temperature modeling of existing conditions for years 2000 through 2004 at several 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. 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, has 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. This reduction in range is largely the result of warmer minimum daily water temperatures because the influence of cool groundwater is reduced.

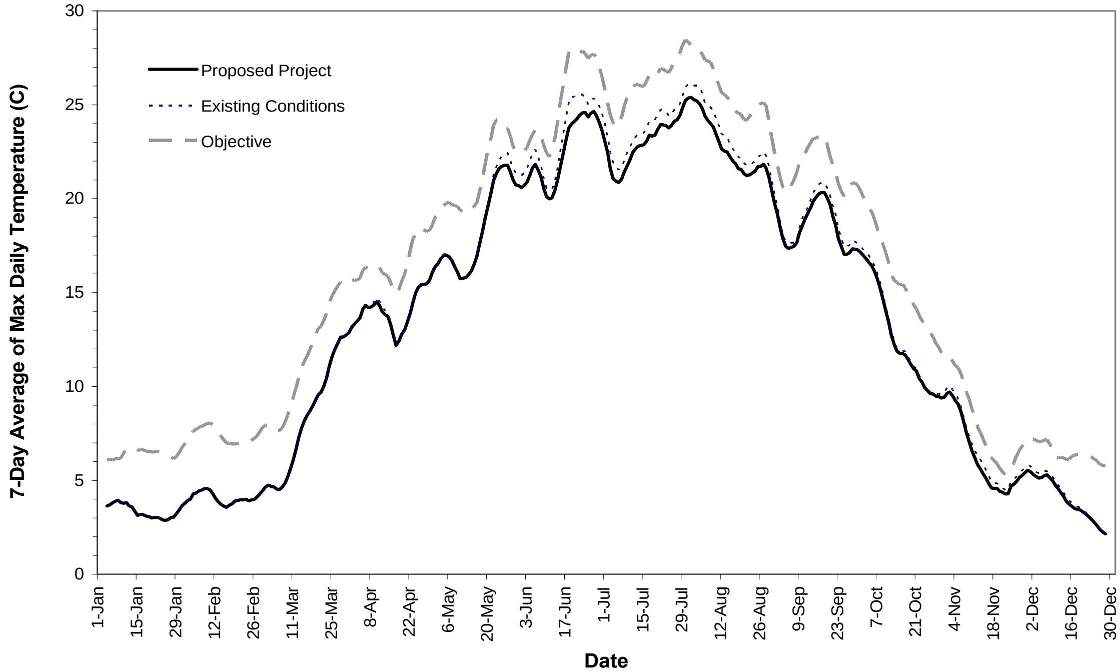
Figures 5.2-19 and 5.2-20 provide the annual time-series of water temperature under existing and proposed Project operation conditions in the Klamath River at Stateline and above Copco reservoir for the years 2000 and 2001. The figures provide a comparison of water temperatures under existing and proposed 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[28] 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.





28 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 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]).



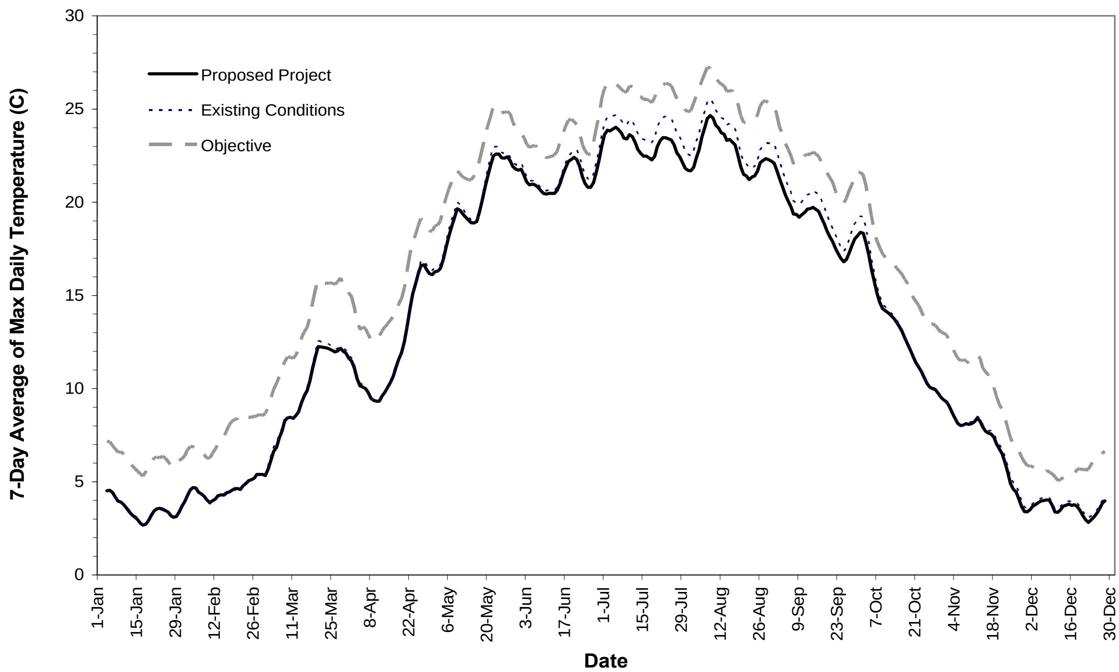


Figure 5.2-20. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the Year 2000 (top plot) and 2001 (bottom plot) in the Klamath River above Copco Reservoir (RM 203.6), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical 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 5.2-15 and 5.2-16). 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 5.2-17). 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 5.2-17).

Figure 5.2-21 shows the annual time-series of water temperature at Copco dam (for the years 2000 and 2001) under existing or proposed[29] 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 5.2-22 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. During occasional brief periods in the fall from about mid-September to mid-November, the temperature can exceed the objective by about 0.1 to 1.5°C. PacifiCorp plans to implement actions and measures as described in the RMP (Appendix B), in consultation with the State Water Board and other applicable regulatory agencies, to address these temperature effects.

[29] For Figures 5.2-21 and 5.2-22, the predicted temperatures under existing and proposed Project operations conditions are coincident.

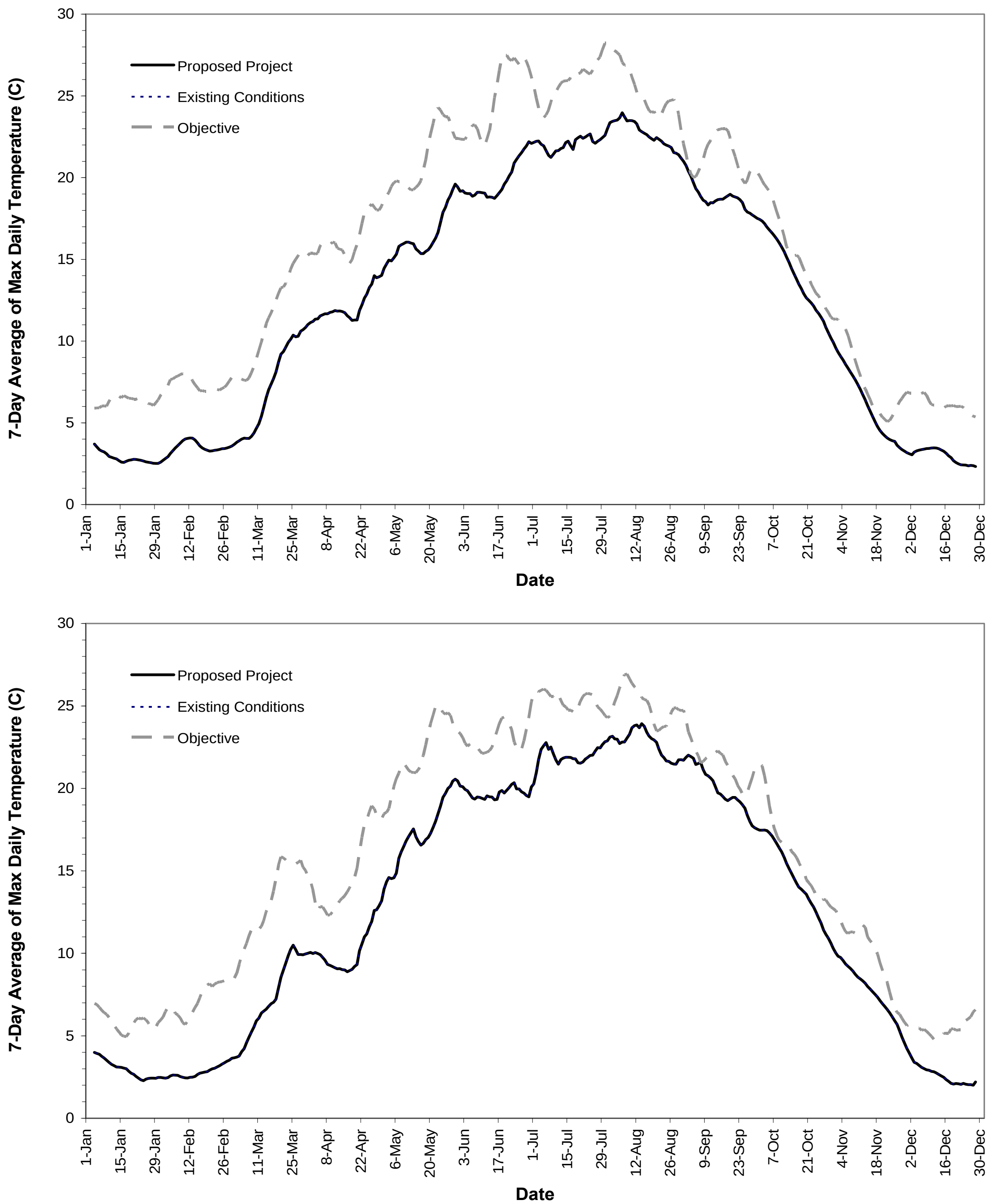


Figure 5.2-21. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Copco No. 1 dam (RM 198.6), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical 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. Controllable water quality factors may provide limited opportunities to bring temperatures more in line with these fluctuating natural conditions through selective withdrawal and other temperature management strategies as described in the RMP (Appendix B) to reduce the magnitude and duration of deviations to protect of COLD beneficial uses.

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 5.2-18). Continuing downstream, the annual maximum water temperatures are generally similar at Seiad Valley (RM 129) and at the Salmon River (RM 67) (Figure 5.2-18), 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, other tributaries).

Figures 5.2-23, 5.2-24, 5.2-25, and 5.2-26 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 5.2-23), at Seiad Valley (RM 129.0; Figure 5.2-24), just above the Salmon River (RM 66.9; Figure 5.2-25), and at Turwar (RM 5.3; Figure 5.2-26). NOTE: the predicted temperatures under existing and proposed Project operations conditions are coincident in Figures 5.2-23, 5.2-24, 5.2-25, and 5.2-26.

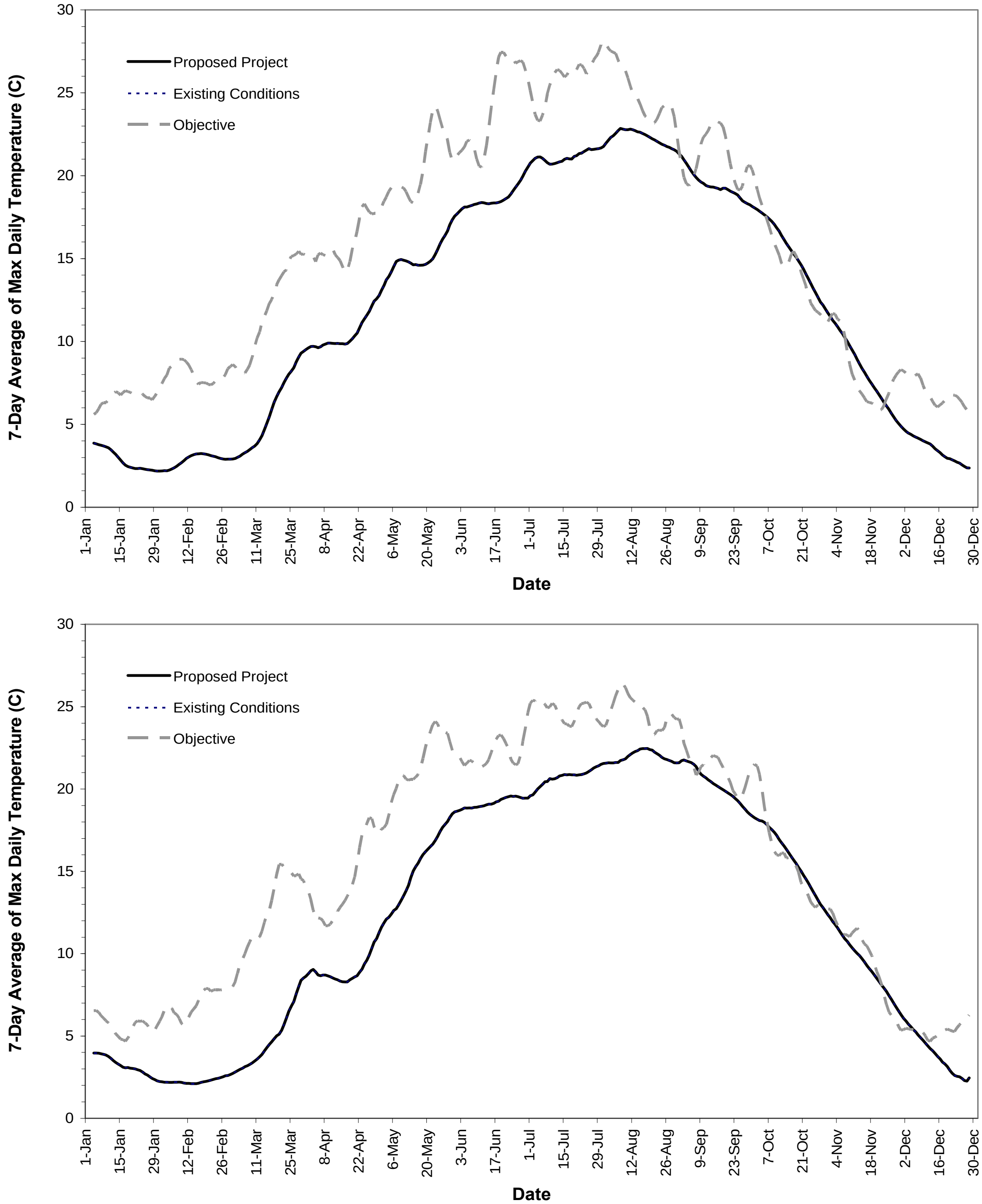


Figure 5.2-22. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Iron Gate dam (RM190), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

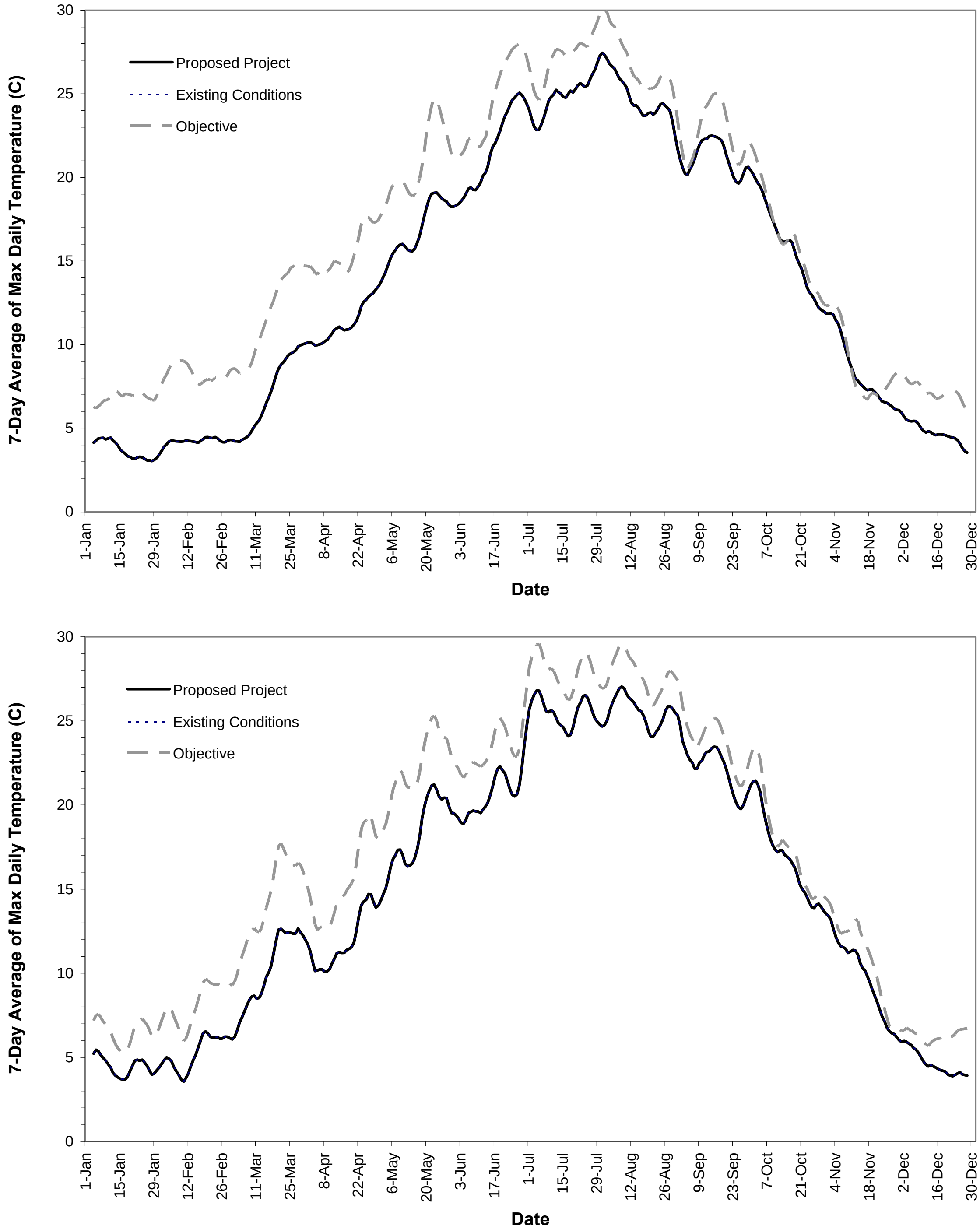


Figure 5.2-23. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at the Scott River (RM 144), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

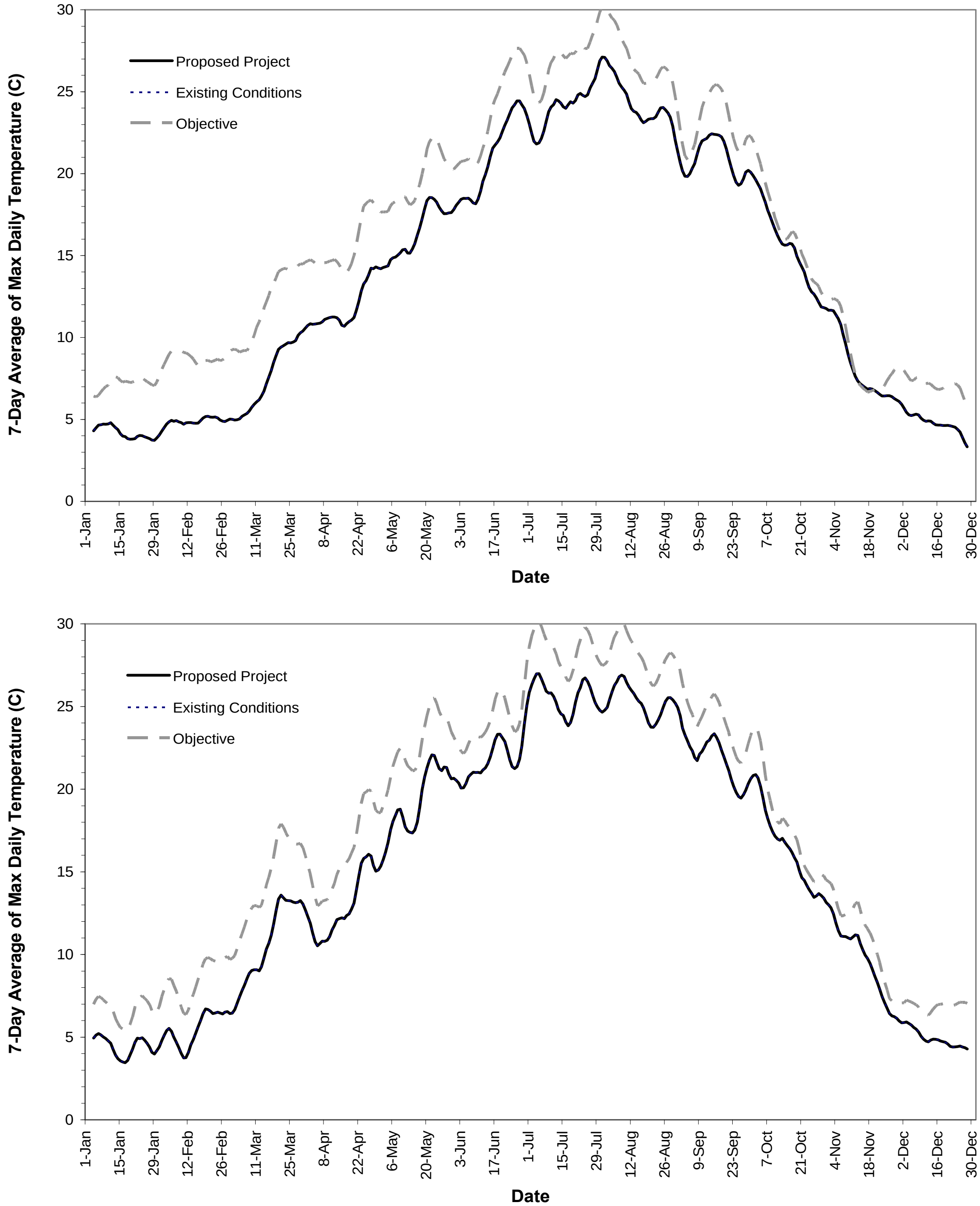


Figure 5.2-24. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Seiad Valley (RM 129), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

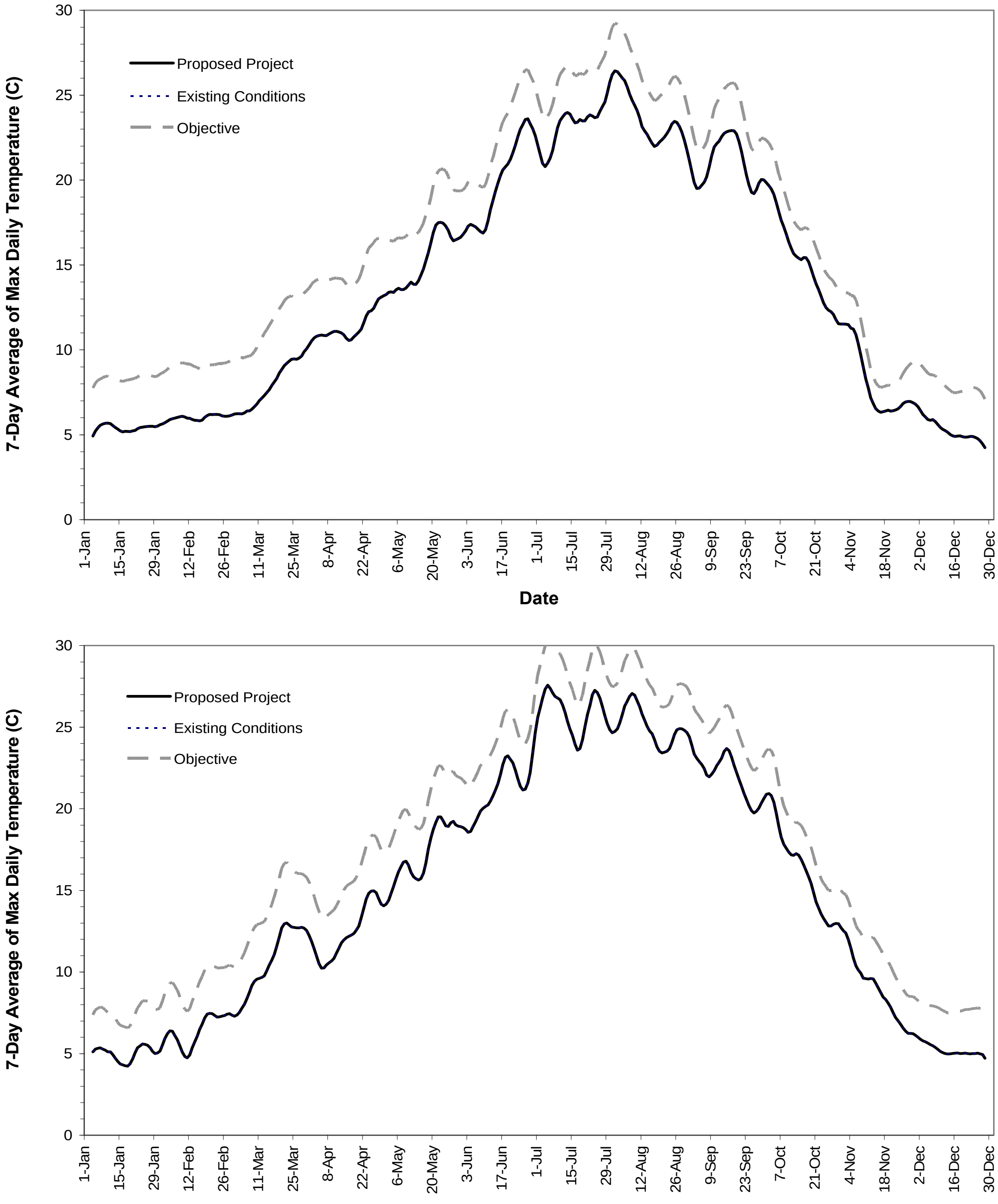
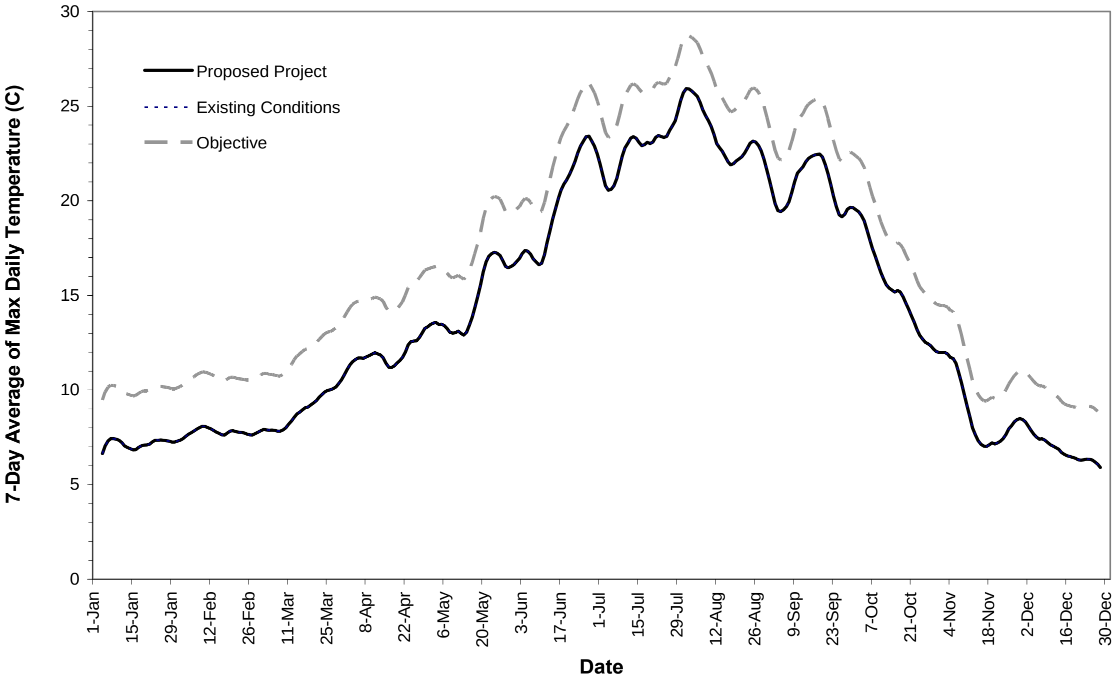


Figure 5.2-25. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at the Salmon River (RM 66.9), compared to the California Temperature objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).



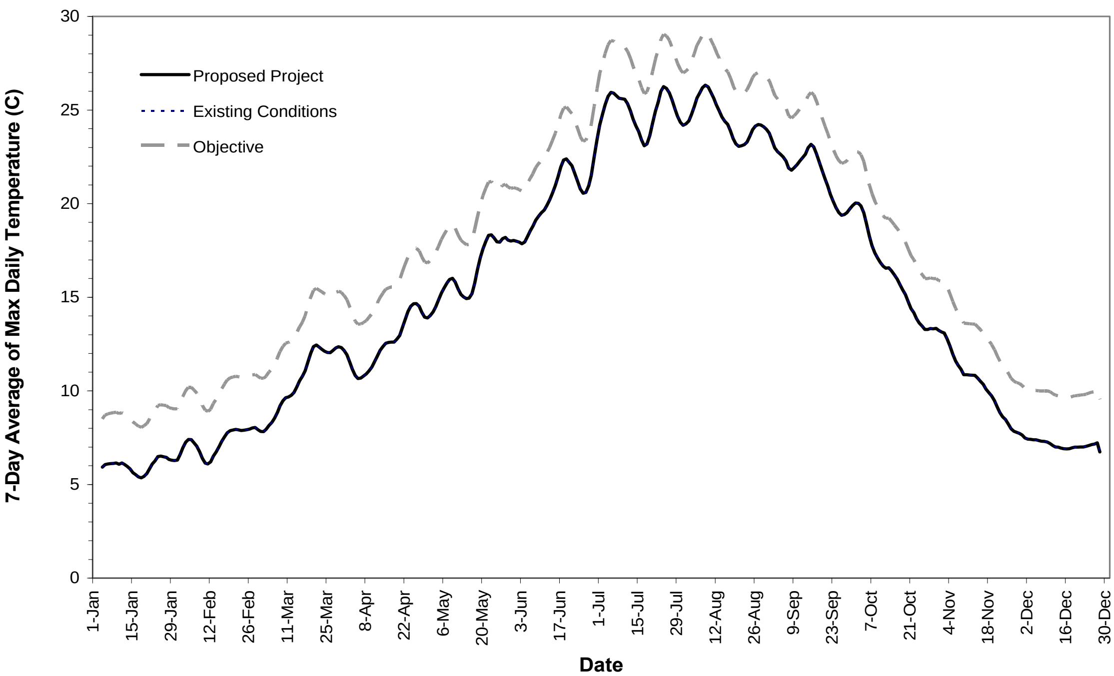


Figure 5.2-26. Time-series of the 7-day Average of Maximum Water Temperature (in degrees C) for the year 2000 (top plot) and 2001 (bottom plot) in the Klamath River at Turwar (RM 5.3), compared to the California Temperature Objective (i.e., no more than 5ºF [2.8ºC] increase above hypothetical without-Project water temperatures [based on model simulations]).

For the Scott River and Seiad Valley locations (Figures 5.2-23 and 5.2-24), 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 5.2-25 and 5.2-26), 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.

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 5.2-9 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).

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.

Table 5.2-9. 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.

The seasonal distribution of the various salmonid life-history stages in the Klamath River assumed in the assessment are presented in Table 5.2-10. The seasonal periodicity assumptions reflect when various life stages of a target species will occur in the river and when life stage-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 life stage of fall-run Chinook salmon and other salmonids).

Table 5.2-10. 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/Life stage	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 to October (Table 5.2-10). 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 effect 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 5.2-11). 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 5.2-12) 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 5.2-12).

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, former Iron Gate Hatchery Manager, CDFW).

Table 5.2-11. 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

*Life stage ends 12/15/2001, but for the sake of including the period from 12/19/2001 through the end of the life stage, this date is also shown

suitable: <17°C	low to moderate stress: 17-21 °C	high stress: >21 °C

Table 5.2-12. 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 5.2-10). 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 5.2-12) 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 5.2-13 presents a comparison of habitat suitability conditions for egg incubation under existing and without Project conditions assuming temperature suitability criteria presented in Table 5.2-9. 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 5.2-10). 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 5.2-13. 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.

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**
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

*Life stage ends 1/15/2001, but for the sake of including the period from 1/7/2001 through the end of the life stage, 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 5.2-12).

Table 5.2-14 presents a comparison of habitat suitability at various locations within the river for juvenile rearing and emigration based on temperature criteria presented in Table 5.2-9. 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 5.2-14. 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

* Life stage ends 7/01/2001, but for the sake of including the period from 7/05/2001 through the end of the life stage, this date is also shown

suitable: <15°C	low to moderate stress: 16-23 °C	high stress: >23 °C

In the 2007 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^{o}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^{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.

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 life stages, 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 5.2-9).

Adult coho salmon upstream migration within the Klamath River occurs from approximately mid-September through January (Table 5.2-10). 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 5.2-15). 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 5.2-15). Overall habitat suitability for adult coho migration within the mainstem Klamath 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 5.2-10). 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 5.2-16) 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 5.2-13).

Juvenile coho salmon rear within freshwater rivers and tributaries throughout the year (Table 5.2-10). 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 5.2-17). 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 5.2-17).

Juvenile coho emigration using the mainstem Klamath River as a migratory corridor occurs during the period from February through July (Table 5.2-10). 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 5.2-17). 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 Klamath 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°C by mid-September, which coincides with the start of the adult coho salmon migration, and that water temperatures are typically below 17°C when coho salmon migration peaks between late October and mid-November.

Table 5.2-15. 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.

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
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

*Life stage ends 1/31/2001, but for the sake of including the period from 2/2/2001 through the end of the life stage, this date is also shown.

suitable: <17°C	low to moderate stress: 18-21 °C

Table 5.2-16. 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.

		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**
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

*Life stage ends 4/30/2001, but for the sake of including the period from 5/2/2001 through the end of the life stage, this date is also shown.

suitable: <12°C	low to moderate stress: 13-14 °C	high stress: >14 °C

Table 5.2-17. 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
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 5.2-17. 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
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

*Life stage ends 4/30/2001, but for the sake of including the period from 5/2/2001 through the end of the life stage, 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 5.2-10). 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 5.2-18). 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 5.2-10). 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 5.2-19). 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 5.2-12).

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 5.2-10). As discussed above, seasonal water temperature conditions significantly affect habitat quality and availability for juvenile rearing within the mainstem Klamath 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 5.2-20). 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 5.2-18. 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

*Life stage ends 11/30/2000, but for the sake of including the period from 11/24/2001 through the end of the life stage, this date is also shown.

suitable: <17°C	low to moderate stress: 18-21 °C	high stress: >21 °C

Table 5.2-19. 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 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
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 5.2-19. 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.

		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**
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

* Life stage ends 6/30/2000, but for the sake of including the period from 6/29/2001 through the end of the life stage, 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 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
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 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

Life stage ends 6/30/2000, but for the sake of including the period from 6/29/2001 through the end of the life stage, 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 5.2-10). 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 5.2-20). 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 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

Regarding the Klamath River reach in California from Stateline to Copco reservoir, PacifiCorp proposes to maintain an instream flow of approximately 320 cfs prior to the presence of anadromous fish within this reach. When anadromous fish are present in this reach, the instream flow releases will be increased to approximately 520 to 550 cfs in April-May to 420 to 450 cfs in all other months (including spring flow input of approximately 220 to 250 cfs within the reach). PacifiCorp proposes to follow this instream flow release schedule during these two periods during the term of the new license[30].

Also regarding the Klamath River reach in California from Stateline to Copco reservoir, PacifiCorp proposes to continue current peaking operations at the J.C. Boyle powerhouse prior to the presence of anadromous fish within this reach. However, the Project-controlled daily flow variation (i.e., the difference between lowest and highest flow in a 24-hour period) will not exceed 1,425 cfs (as measured at the USGS gage below the J.C. Boyle powerhouse). The limit of operations-related flow variation to 1,425 cfs per daily period will bring an end to two-unit peaking events where the powerhouse goes from off (i.e., approximately 320 cfs at the USGS gage) to two-unit full load (i.e., 2,850 cfs from the powerhouse, and approximately 3,270 cfs at USGS gage) in a 24-hour time period. This does not preclude two-unit operation if inflows are high enough to run both units or have one unit in operation and the second one operated in a peaking fashion.

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 Klamath River reach in California from Stateline to Copco reservoir 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).

[30] In May 2010, PacifiCorp, the Klamath Tribes, and the U.S. Bureau of Indian Affairs (BIA) entered into a water right settlement agreement resolving the Klamath Basin Adjudication (KBA) Cases 282 (Klamath River) and 286 (Upper Klamath Lake). The parties agreed to this instream flow release schedule during these two periods: (1) an interim period prior to the presence of anadromous fish in the Klamath River below J.C. Boyle dam and powerhouse; and (2) the subsequent period when anadromous fish are present in the Klamath River below J.C. Boyle dam and powerhouse.

Copco and Iron Gate Reservoirs

As discussed in Section 3.2.4 and the RMP (Appendix B), PacifiCorp will evaluate (in consultation with the State Water Board) the effectiveness and feasibility of the implementation of selective intake withdrawal control 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. PacifiCorp's FLA (PacifiCorp 2004b) describes a potential measure to implement a low-level release of cooler hypolimnetic water from Iron Gate reservoir during late summer and fall 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. In addition, the 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 have effects on the hatchery that would need to be addressed.

PacifiCorp proposes to conduct additional evaluation and testing of intake withdrawal control, specifically in Iron Gate reservoir as described in the RMP (Appendix B). Such additional evaluation and testing is needed to gain better reliability and effectiveness information prior to further design and potential implementation of selective intake withdrawal for water temperature control.

Klamath River below Iron Gate Dam

As described in Section 2.5.2.2 above, PacifiCorp is in the process of implementing the conservation measures and activities as set forth in the coho HCP (PacifiCorp 2012). A key component of the HCP includes the selection and implementation of actions and activities to enhance thermal refugia habitats at tributary mouth along the Klamath River below Iron Gate dam funded through PacifiCorp's Coho Enhancement Fund. The actions and activities implemented under the coho HCP will continue over the interim period until the dams are removed pursuant to the Klamath Hydroelectric Settlement Agreement or, should dam removal not proceed, until a new FERC license is issued. Therefore, there is currently no plan to continue the coho HCP actions and activities under a new FERC license and the associated 401 water quality certification for the Project. However, it is expected that various fish habitat enhancements implemented under the coho HCP, including the thermal refugia habitat enhancements, will be durable and provide biological benefits into the future even after the interim coho HCP actions and activities cease. As such, the on-going biological benefits from these interim actions will continue to contribute to the proposed Project's protection of designated uses (as discussed in this Section 5.1) and water quality objectives as set forth in the Basin Plan.

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 total dissolved solids in 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 5.2-21.

Table 5.2-21. 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	131	191
Minimum	76	6
1st Quartile	114	169
Median	131	188
3rd Quartile	148	212
Maximum	183	354

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, which has not identified total dissolved solids as a contributing to egg fertilization and hatching issues.

5.2.4.4 Proposed Measures

Even though there is no water quality objective specified for the relevant segments of the Klamath River, total dissolved solids 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 FLA Exhibit E (PacifiCorp 2004b) 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 5.2-22 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 5.12-22). 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 Upper Klamath Lake, 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 5.2-22. 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 reservoir in Oregon, and Copco and Iron Gate reservoirs in California. 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.

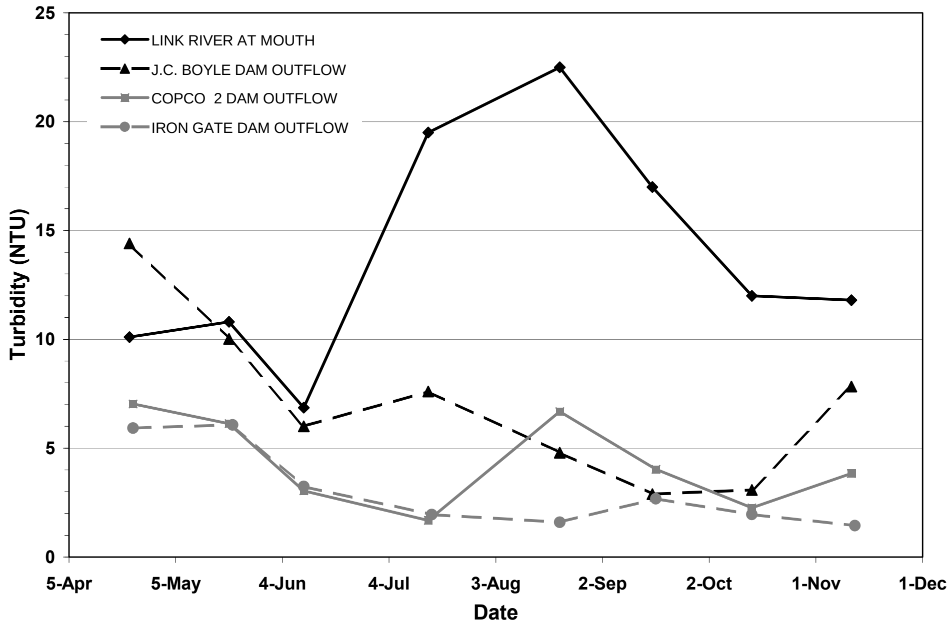


Figure 5.2-27. Turbidity values from samples taken during April-November 2003 at the mouth of Link River (RM 253), the Klamath River below J.C. Boyle dam (RM 224), the Klamath River below Copco No. 2 dam (RM 196.5), and the Klamath River below Iron Gate dam (RM 189.5).

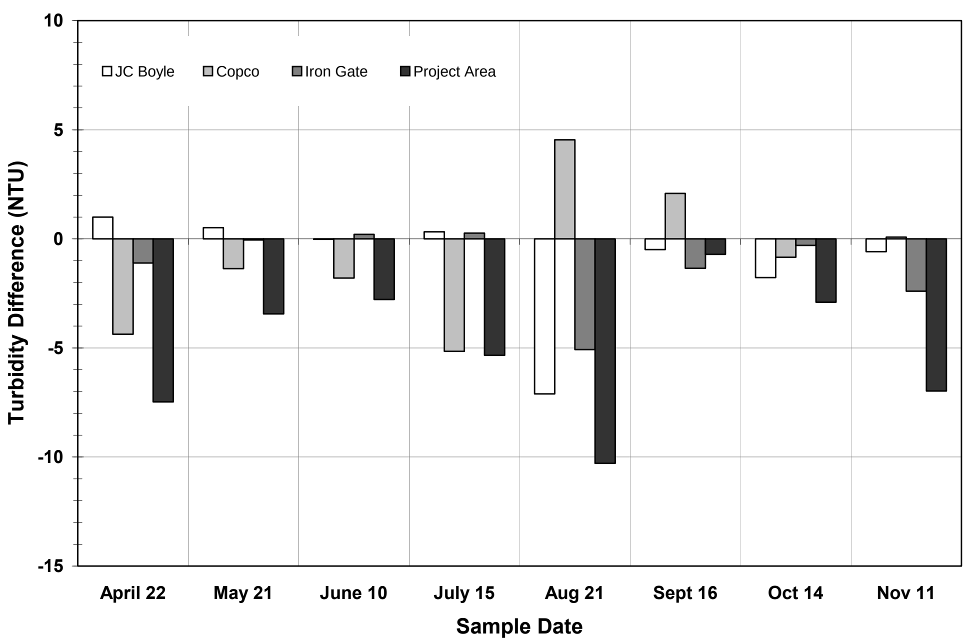


Figure 5.2-28. Differences in turbidity samples taken during April-November 2003 above and below J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and for the Project area (above J.C. Boyle reservoir to Iron Gate dam outflow).

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 Klamath River. PacifiCorp also proposes to eliminate two-unit peaking operations at the J.C. Boyle powerhouse, which will substantially reduce ramping and potential related turbidity increases, if any, in the reach of the Klamath River in California between Stateline and Copco reservoir. 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[31] water (80 PCU) in the Klamath River below Keno dam (RM 234) in Oregon, 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

[31] 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.

dam is not surprising given the high organic loading to the river from hypereutrophic Upper Klamath Lake and other upstream sources, particularly during summer.

The relatively low-colored water (27 PCU) in the Klamath River in the lower end of the J.C. Boyle bypass reach in Oregon reflects the substantial spring flow accretion in the J.C. Boyle 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[32]).

The appreciable reduction in color from Keno dam (80 PCU) in Oregon to Iron Gate dam (34 PCU) in California cannot be fully explained by the dilution effects of flow accretion between these two locations (from RM 234 to RM 190). USGS gage records show that average flows from August 9 to 11, 2004, were approximately 350 cfs at the Keno gage and 615 cfs at the Iron Gate gage. If accretion inputs between these locations were assumed to have a color of 10 PCU (as back-calculated for J.C. Boyle 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[33]. 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) in Oregon, 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)[34]. 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 solids (TSS) as described in PacifiCorp's FLA (PacifiCorp 2004a, 2004b).

The lower light penetration (2.6 m^{-1}) in the Klamath River below Keno dam is not surprising given the high organic loading to the river from hypereutrophic Upper Klamath Lake 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 J.C. Boyle bypass reach in Oregon reflects the dominance of substantial spring flow accretion in the J.C. Boyle 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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32 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).

33 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.

34 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}.

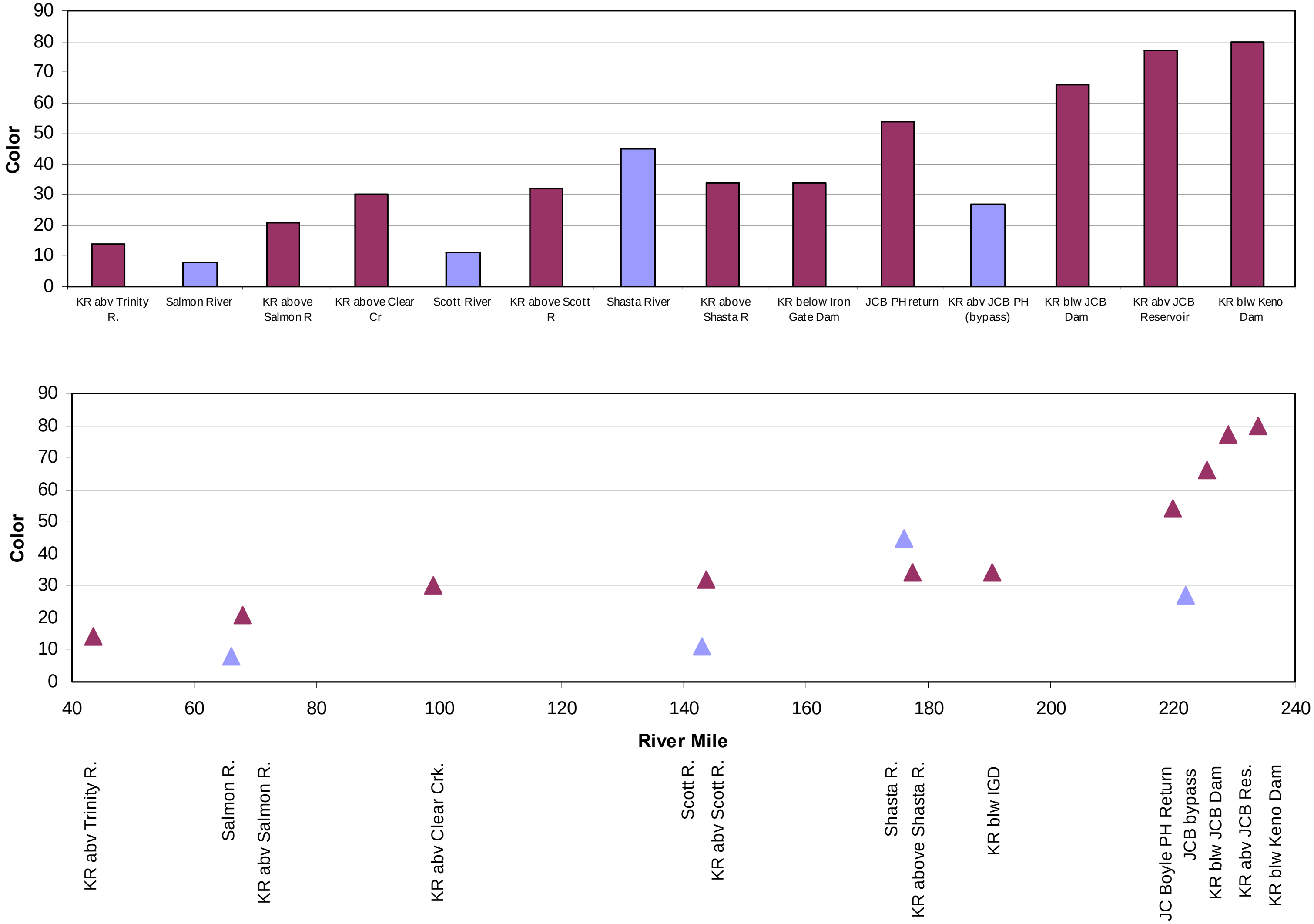


Figure 5.2-29. Color in water (Platinum-Cobalt units) at various locations in the Klamath River measured August 9-11, 2004.

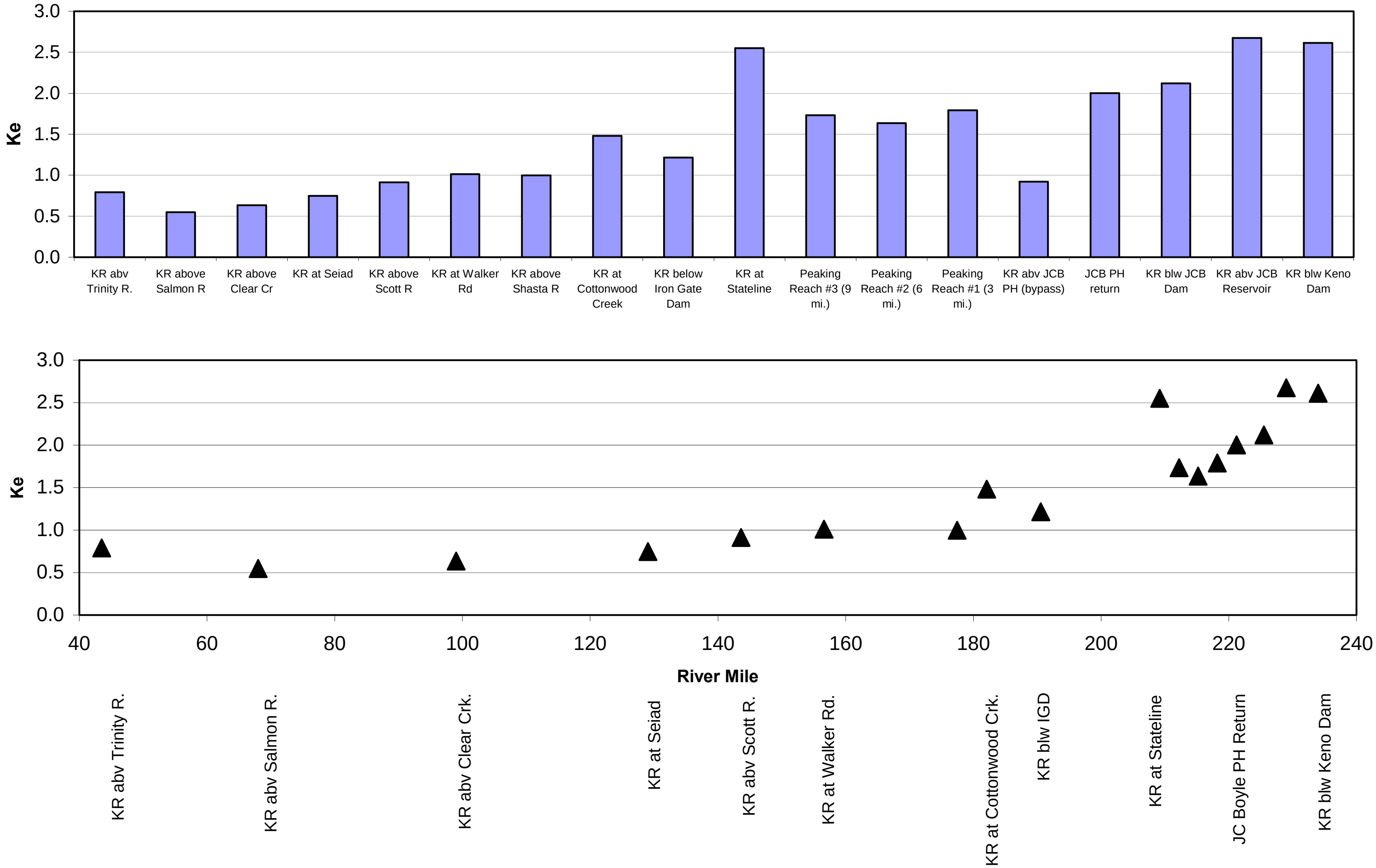


Figure 5.2-30. Light extinction coefficients (Ke; 1/m) at various locations in the Klamath River measured August 9-11, 2004.

5.2.6.3 Project Contribution

No physical activity or biological process associated with the Project increases the color of water.

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, while the reservoirs provide lacustrine conditions where phytoplankton grow, any such abundant algae growth is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake. 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 caused nuisance or adversely affected beneficial uses in the Klamath River, including related to 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 in Oregon 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 coves 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, while the reservoirs provide lacustrine conditions where phytoplankton grow, any such abundant algae growth is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake. The Project itself adds no nutrients to the water that would result in the production of surface foam or floating material. 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 floating material issues that may be associated with that algae.

5.2.8.4 Effects on Fish and Aquatic Life

There is no evidence or information to suggest that floating material has caused nuisance or adversely affected beneficial uses in the Klamath River, including related to salmonids or other freshwater aquatic species.

5.2.8.5 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 on-going monitoring 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 Project reservoirs resulting from contribution of nutrients and organic matter from non-Project-related upstream sources.

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 5.2-23.

Table 5.2-23. Summary statistics for total suspended solids values measured in the Klamath River between Stateline 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.

5.2.9.4 Effects on Fish and Aquatic Life

There is no evidence or information to suggest that suspended material has caused nuisance or adversely affected beneficial uses in the Klamath River, including related to salmonids or other freshwater aquatic species.

5.2.9.5 Proposed Measures

PacifiCorp proposes no specific measures with respect to suspended material, although the proposed RMP 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 (including based on numerous 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 has caused nuisance or adversely affected beneficial uses in the Klamath River, including related to salmonids or other freshwater aquatic species.

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 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

Upper Klamath Lake is subject to large blooms of phytoplankton, and exports large quantities of algae, organic matter, and 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 Upper Klamath Lake 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. 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 include large loads of nutrients that promote algal growth (NCRWQCB 2010).

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 (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b). 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 (PacifiCorp 2004e, PacifiCorp 2006, PacifiCorp 2008b, Raymond 2008a, Raymond 2008b).

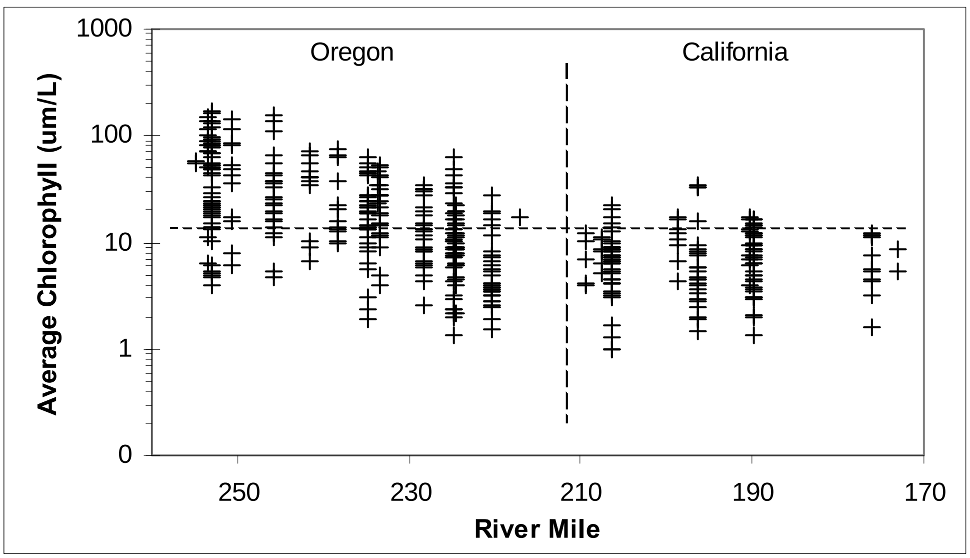


Figure 5.2-31. Average chlorophyll-*a* concentration of sequential sets of three consecutive monthly values for data collected from 2000 through 2005 at various locations in the Klamath River between Upper Klamath Lake (RM 254.8) in Oregon and the I-5 Bridge (RM 176) in California. Note the logarithmic 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.

Chlorophyll-*a* data in the mainstem Klamath River downstream from Upper Klamath Lake follow a longitudinal pattern where concentrations tend to be highest (and most variable) at the outflow from Upper Klamath Lake at Link dam (RM 253.1) and decrease progressively through Keno dam (RM 235), J.C. Boyle dam (RM 224.8), Copco No. 1 dam (RM 198.7), Iron Gate dam (RM 190.2), and the Klamath River near the I-5 Bridge (RM 179.2)(Figure 5.2-31). High chlorophyll-*a* concentrations of up to 200 µg/L at the outflow from Upper Klamath Lake are due to large blooms of algae entering the Klamath River from the lake (ODEQ 2002, ODEQ 2010, Sullivan et al. et al. 2010).

The longitudinal pattern and high concentrations chlorophyll-*a* correlate directly to the nutrient-enriched conditions and organic matter concentrations in Upper Klamath Lake and the large loads of nutrients from the lake to the river. As described in Section 4.2 above, phosphorus and nitrogen data show similar longitudinal patterns and high concentration trends (for example, see Figure 4.2-1 in Section 4.2). Therefore, the discussion of biostimulatory substances in this section focuses on the nutrients phosphorus and nitrogen.

Klamath River from Stateline to Copco Reservoir

Summary statistics for the concentrations of nutrients measured in the Klamath River upstream of Copco reservoir near Shovel Creek (RM 206) are presented in Table 5.2-24. The concentrations of nutrients in the reach of the Klamath River between Stateline and Copco reservoir are dominated by the nutrient loads that emanate from Upper Klamath Lake (ODEQ 2010, NCRWQCB 2010). The concentrations of nutrients in this reach can change somewhat from mostly spring-fed groundwater when the J.C. Boyle powerhouse is not operating, to dominantly Klamath River water originating from Upper Klamath Lake when the powerhouse is operating. As described in Section 4.2.7.3 above, total nitrogen, phosphorus, and organic carbon are all lower at the bottom of this reach than at the top. The reduction is mostly the result of dilution of Upper Klamath Lake water by the springs below J.C. Boyle dam.

Table 5.2-24. 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 (PacifiCorp 2006, Asarian et al. 2009). For example, over a two-year study period (i.e., April 2005-April 2007), Asarian et al. (2009) determined that Copco reservoir retained about 35 metric tons of total phosphorus (equivalent to about 7 percent of the inflow load) and 374 metric tons of total nitrogen (also about 7 percent of the inflow load).

The effect of upstream nutrient loads 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, although the reservoir retains nutrients over the long term (e.g., months, years) as described above. For example, following an algae bloom event in the upper system (e.g., in Upper Klamath Lake or Keno reservoir in Oregon), poor water quality conditions abate, and inflowing waters to Copco begin to improve. Simultaneously, however, Copco reservoir outflow water quality will still be responding to previous inputs of nutrients and organic matter from upstream sources.

Summary statistics for nutrient concentration measured in Copco reservoir are presented in Table 5.2-25. Median values for nutrients measured at different depths are presented in Table 5.2-26.

Table 5.2-25. 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 5.2-26. 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 directly to Iron Gate reservoir are insignificant in comparison to Klamath River inflows. As with Copco reservoir, Iron Gate reservoir acts as an annual net sink for portion of the large inflow loads of total phosphorus and total nitrogen (PacifiCorp 2006, Asarian et al. 2009). For example, over a two-year study period (i.e., April 2005-April 2007), Asarian et al. (2009) determined that Iron Gate reservoir retained about 23 metric tons of total phosphorus (equivalent to about 4 percent of the inflow load) and 304 metric tons of total nitrogen (about 6 percent of the inflow load). For Iron Gate and Copco reservoirs in combination, Asarian et al. (2009) determined that the reservoirs together retained about 58 metric tons of total phosphorus (about 11 percent of the inflow load) and 678 metric tons of total nitrogen (about 12 percent of the inflow load).

The effect of upstream nutrient loads 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 (PacifiCorp 2006). 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, although the reservoir retains nutrients over the long term (e.g., month, years) as described above. The annual contribution to the reservoir's nutrient loading from internal reservoir nutrient cycling (e.g., nutrient release from sediments under anoxic conditions) is probably not significant, due to: (1) the comparatively large hydraulic and nutrient loads from the inflowing Klamath River; (2) the complete replacement of reservoir volume during winter periods; and (3) the reservoir's persistent stratification during the algae growth season.

Summary statistics for nutrient concentration measured in Iron Gate reservoir are presented in Table 5.2-27. Median values for nutrients measured at different depths are presented in Table 5.2-28.

Table 5.2-27. 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 5.2-28. 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. However, the concentrations of nitrate and orthophosphate are steadily reduced with distance from Iron Gate dam. For example, Figure 4.2-1 (in Section 4.2 above) shows a steady downriver decline in DOC, total phosphorus, and total nitrogen along Klamath River monitoring sites from RM 189.7 near Iron Gate dam to the mouth. This condition is partly due to dilution, but also in response to uptake from seasonal periphyton growth in the river. The river channel from Iron Gate dam (RM 190) to near Happy Camp (RM 103) supports seasonally abundant periphytic growth of eutrophic diatoms, including the more prevalent species *Cocconeis placentula*, *Nitzschia frustulum*, *Navicula cryptocephala veneta*, and *Rhoicosphenia curvata* (Asarian et al. 2014).

The rate of nutrient reduction in the downstream direction tends to diminish in the vicinity of the Salmon and Trinity Rivers (for example, these locations correspond to approximately RM 59.1 and RM 43.5 monitoring locations, respectively, represented in Figure 4.2-1). The decrease in the rate of nutrient reduction 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, potential light limitation with increasing river depth, dilution, annual disturbance due to sediment transport, or other factors. For example, nitrogen limitation in the lower river favors periphyton species adapted to lower nutrient conditions, such as the nitrogen-fixing diatoms *Epithemia sorex*, *Epithemia turgida*, and *Rhopalodia gibba*, which can dominate in the lower river in summer and early fall (Asarian et al. 2014).

Nutrient concentrations also indicate seasonal variations with lower concentrations in early spring, increasing through summer and fall (Deas 2008, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013). This condition is probably due to both dilution from tributaries during the wetter months as well as seasonal fluxes from upstream during warmer months.

Summary statistics for nutrient concentration measured in the Klamath River below Iron Gate dam near the I-5 Bridge (RM 176) are presented in Table 5.2-29.

Table 5.2-29. 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 segments of the river and reservoirs in California are largely the result of input from upstream sources, particularly Upper Klamath Lake. Physical and biological processes in the river and reservoirs can modify the forms of nutrients (for example, the conversion from organic to inorganic forms) and to an extent the amounts of nutrients (for example, through reservoir sedimentation and retention).

PacifiCorp's relicensing studies (PacifiCorp 2004a, 2004h) and other more recent analyses (PacifiCorp 2006, Kann and Asarian 2005, Kann and Asarian 2007, Asarian et al. 2009) provide substantial evidence that the reservoirs act as a net sink for nutrients (nitrogen and phosphorus) through reservoir sedimentation and retention. For example, the total annual net retention of nutrients in Copco and Iron Gate reservoirs is presented in Table 5.2-30 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.

These analyses (as well as additional subsequent analysis by Asarian et al. 2009) 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.)

Table 5.2-30. 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).

Constituent	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	
	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

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.)

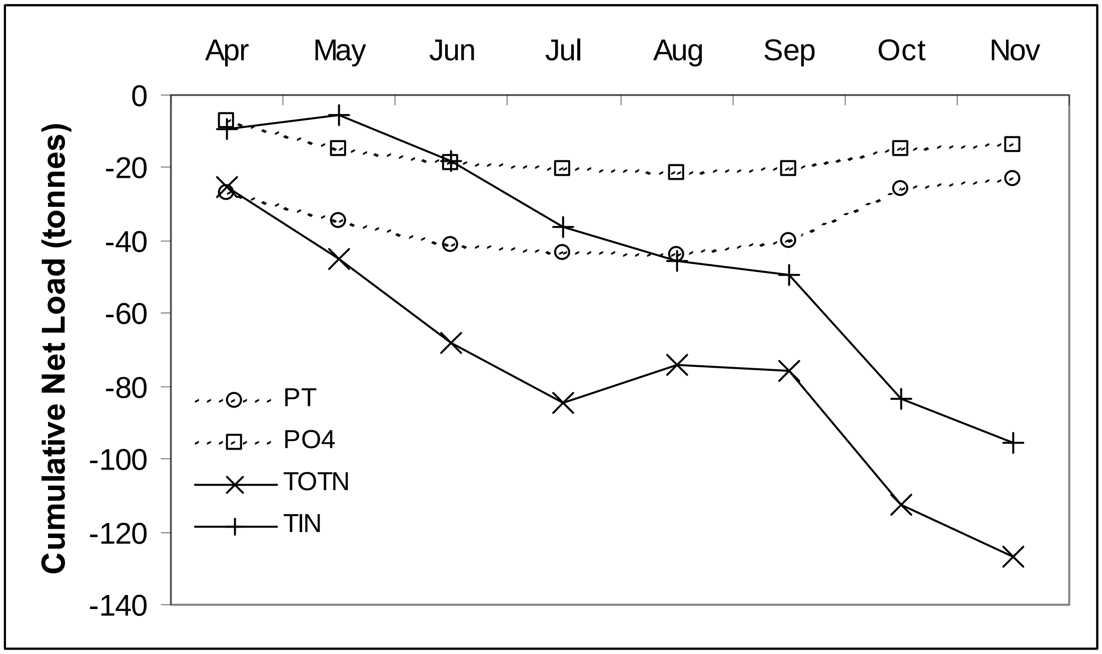


Figure 5.2-32. The cumulative difference in nutrient load (tons) between the Klamath River above Copco and the Klamath River below Iron Gate Dam. A negative value indicates that the load at Iron Gate is less than the load above Copco. (Data from Kann and Asarian, 2005).

Asarian and Kann (2006) assessed nitrogen[35] 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 Gate dam are summarized in Table 5.2-31. 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 5.2-31. 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**	--	--	--	--	--	--

35 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).

Table 5.2-31. 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
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 5.2-31 indicates 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 5.2-31). 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 5.2-31). 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. Also, Oliver et al (2014) identify nitrogen decreases seasonally downstream in the Klamath River during algae bloom and post-algae bloom periods.

5.2.11.4 Effects on Fish and Aquatic Life

As described above, large loads of nitrogen and phosphorus in the Klamath River system stimulate algal production and contribute to eutrophic conditions. During the growing season (i.e., spring through early fall), the large loads of nutrients contribute to extensive periphyton growth in the Klamath River reaches in California (such as between Stateline and Copco reservoir and downstream of Iron Gate dam), and high phytoplankton production in Copco and Iron Gate reservoirs. However, while Copco and Iron Gate reservoirs provide lacustrine conditions where phytoplankton grow, the high phytoplankton production in the reservoirs are primarily caused by the large loads of nutrients flowing into the Project area from upstream. Such high algal production within the system contributes to water quality changes that can affect habitat for salmonids and other fish and invertebrates, including 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.

5.2.11.5 Proposed Measures

As described above, the Project does not contribute to the large loads of nutrients from upstream sources that stimulates the growth of periphyton and phytoplankton in the Klamath River system in California. While Copco and Iron Gate reservoirs provide lacustrine conditions where phytoplankton grow, the high phytoplankton production and eutrophic conditions are primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake. Control of the large inflow loads of nutrients and organic matter from upstream sources is most appropriately addressed through controls on those sources, primarily upstream in Oregon, for example through the implementation of appropriate TMDLs developed by ODEQ (2010).

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. These actions and activities include: (1) constructed wetlands conceptual design and implementation planning; (2) further evaluation of tailrace aeration and oxygenation systems; (3) design and implementation planning of reservoir oxygenation systems; (4) evaluation of epilimnion (surface water) mixing and circulation; (5) further evaluation of selective withdrawal and intake control; (6) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoirs; and (7) additional testing and controlled applications of SCP algaecide to treat localized areas (e.g., coves, embayments) in the reservoirs. It is anticipated that these RMP actions and activities will have the effect of reducing nutrients and algae growth, and thus reduce algae production and chlorophyll concentrations within the reservoirs and in downstream releases to the river.

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 5.2-32. 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 5.2-32. Total suspended solids values (mg/L) measured on samples from the Klamath River[36].

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

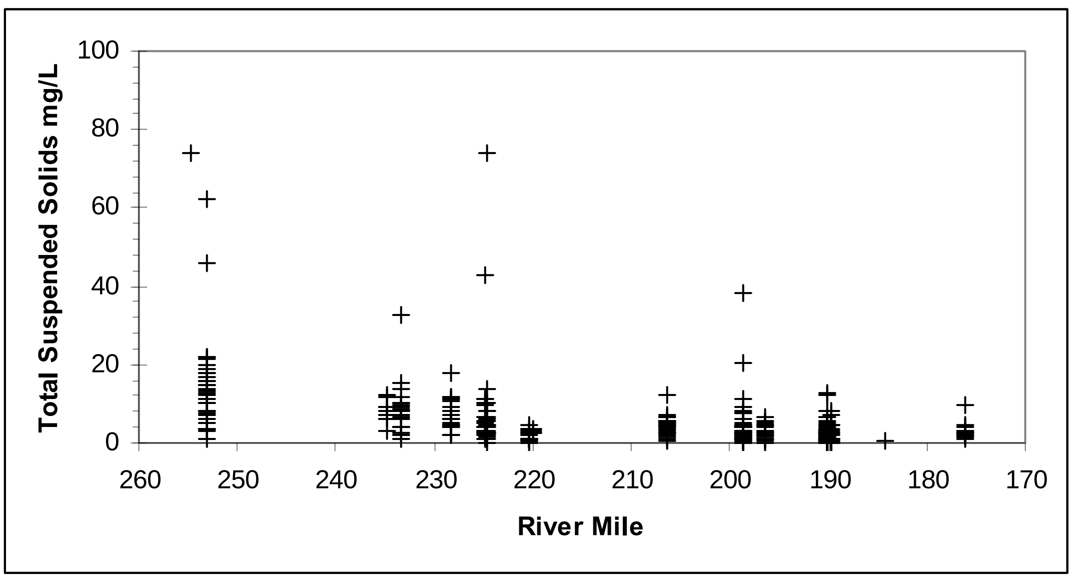


Figure 5.2-33. Total suspended solids measured on samples from the Klamath River between Link River in Oregon and the mouth of the Shasta River in California in 2001 through 2007.

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

[36] Site ID locations in this table include Klamath River sampling sites near the Shasta River (KR17300), near the I-5 Bridge (KR17600), below Iron Gate dam (KR18973), at the Iron Gate reservoir log boom (KR19019), below the Copco 2 powerhouse (KR19645), in Copco reservoir near the dam (KR19874), and above Copco reservoir near Shovel Creek (KR20642).

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 life stages 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 life stages 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. However, there is no evidence or information 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

<u>Cyanobacterial (Blue-Green Algae) Toxins.</u>

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 Upper Klamath Lake that it has supported a major harvesting program to manufacture food supplements. Eilers et al. (2001) suggest that the dominance of *Aphanizomenon* in Upper Klamath Lake has come about in the last century, but cyanobacteria have been a major part of the phytoplankton community for the past 1,000 years. Negative effects of algal blooms in Upper Klamath Lake have been noted since the mid-1800s, and fish kills have been observed for more than 150 years (Wee and Herrick 2005). Conditions in Upper Klamath Lake have a direct influence on conditions in the Klamath River and downstream reservoirs.

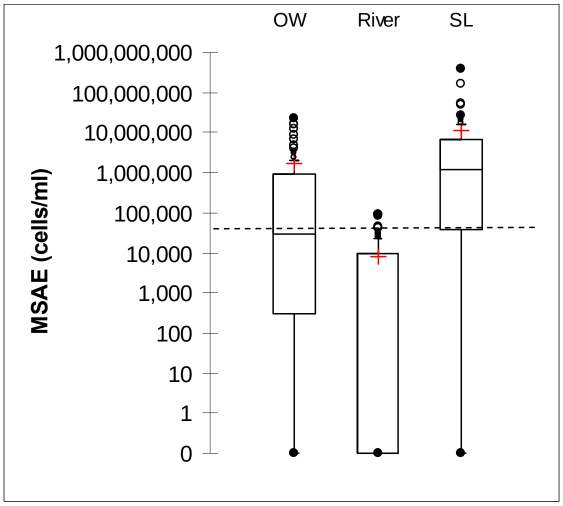
Aphanizomenon flos-aquae is also an abundant species in Copco and Iron Gate reservoirs, as it is in Upper Klamath Lake. Cyanobacteria are a potential nuisance throughout the world because of the ability of some species to produce substances toxic to humans and other organisms. Although *Aphanizomenon* in the Klamath basin does not appear to be toxic, other potentially toxic species have been observed in samples collected from the Klamath basin, including *Microcystis aeruginosa*, *Anabaena flos-aquae*, *Anabaena planctonica*, and *Gloeotrichia echinulata* (PacifiCorp 2004h, Raymond 2008b, Raymond 2009b, Raymond 2010b). Of these, *Microcystis aeruginosa* has been most frequently observed in samples collected from Copco reservoir and Iron Gate reservoir, and at the river stations immediately below these two reservoirs (PacifiCorp 2004h, Raymond 2008b, Raymond 2009b, Raymond 2010b).

Microcystis is of particular interest because of its potential to produce toxins (e.g., microcystin) that can present a public health risk at high concentration (Raymond 2008b, Raymond 2009b, Raymond 2010b). Certain conditions favor *Microcystis* over *Aphanizomenon*. For example, an abundance of ammonia gives a competitive edge to *Microcystis*. Increased *Microcystis* blooms have occurred in recent years in Copco reservoir that are: (1) consistent with the elevated levels of inorganic nitrogen (e.g., ammonia, nitrate) and organic matter in influent waters to Copco reservoir; and (2) coincident with increases in nitrogen in the outflow from Upper Klamath Lake (such as seen in Figure 4.2-18 in Section 4.2).

Figure 5.2-34 shows all the instances when *Microcystis* was observed in Copco or Iron Gate reservoir in samples taken at 0.5 m depth near the dam during 2001 through 2009 as reported by Raymond (2010b). All samples were collected by a uniform protocol comparable between years. Despite some differences in sampling frequency, this graph suggests that *Microcystis* abundance appear to have systematically increased in recent years in the reservoirs. Recent increases in *Microcystis* abundance also have been observed in other locations throughout the Klamath Basin, including upstream in Upper Klamath Lake and Agency Lake (PacifiCorp 2008a, PacifiCorp 2008b, Raymond 2009a, Raymond 2009b, Raymond 2010a, Raymond 2010b, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013, Hoilman et al. 2008, Mioni et al. 2011, Caldwell-Eldridge et al. 2012, Eldridge et al. 2012). Similar recent increases in concentrations of *Microcystis* have been identified in numerous other water bodies in California, including the Eel River, Van Duzen River, Clear Lake, Lake Elsinore, and San Francisco Bay Delta, among others (Lehman et al. 2013, CDPH 2013). Researchers at Oregon State University report that the incidence of toxin-producing cyanobacteria, like *Microcystis*, is rising nation-wide, and appears to be tied to rising temperatures and carbon dioxide concentrations due to climate change, and nutrient enrichment increases in runoff from urban and agricultural lands (Oregon State University 2013).

The distribution of *Microcystis* and microcystin in the Project reservoirs and river is not uniform. Localized high abundance of *Microcystis* 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 *Microcystis* 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 *Microcystis* abundance and microcystin concentration when samples were collected from highly-concentrated surface accumulations. Samples taken from the Klamath River had consistently lower *Microcystis* abundance and microcystin values (Figure 5.2-35). Exposure of pets or humans to highly concentrated algal surface accumulations can 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 *Microcystis* abundance and microcystin and more exceedances of guidance values compared with samples taken in the open waters of the reservoirs or at river (i.e., non-reservoir) sites (Figure 5.2-35).

Figure 5.2-34. *Microcystis aeruginosa* biovolume (µm3/mL) measured on all samples collected in Copco and Iron Gate reservoirs during 2001 through 2009. Two very high values, 18,040,000 µm3/mL in 2004 and 27,598,826 µm3/mL in 2007 have been left off the graph to improve readability. The dashed line at 320,000 µm3/mL represents the approximate biovolume equal to the guideline value of 40,000 cells/mL.



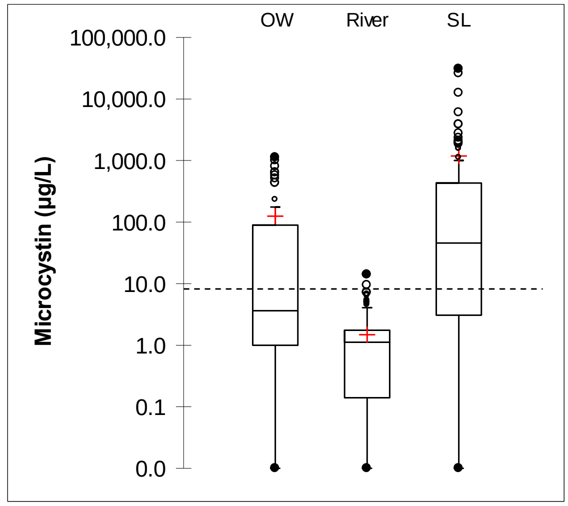


Figure 5.2-35. *Microcystis aeruginosa* abundance and microcystin concentration measured at open water reservoir sites (OW), river (i.e., non-reservoir) sites (River), and reservoir shoreline sites (SL) in the Klamath River in 2005 through 2007 (Kann 2006, Kann and Asarian 2006, Fetcho 2007). The horizontal dashed lines indicate the California recreational waters guidance value for *M. aeruginosa* (40,000 cells/mL) and microcystin (8 µg/L) (SWRCB 2010).

Since 2009, PacifiCorp has been funding a baseline water quality monitoring program under Interim Measure 15 of the KHSA, which includes a public health monitoring component to provide timely information that can be used to inform public health agencies if cyanobacteria and toxins of concern are present, and to determine the need to post warning notices and issue advisories for the Project reservoirs and/or areas of the Klamath River. The California State Water Resources Control Board provides guidelines for posting advisories in recreation water (SWRCB 2010). SWRCB recommends posting advisories in recreation waters under four circumstances: (1) if "scum is present associated with toxigenic species"; (2) if scum is not present, but the density of *Microcystis* or *Planktothrix* is 40,000 cells/ml or greater; (3) if scum is not present, but the density of all potentially toxigenic BGA is 100,000 cells/ml or greater; and (4) if microcystin is 8 µg/L or greater. The monitoring program occurs over approximately 250 miles of river and reservoirs waters from Link dam near Klamath Falls to the Klamath River estuary near Klamath, California throughout most of the year. Annual planning and implementation of this monitoring program is done collaboratively with PacifiCorp, NCRWQCB, ODEQ, USEPA Region 9, the Karuk and Yurok Tribes, and Reclamation.

Figure 5.2-36 shows microcystin levels (µg/L) from Link River to the Klamath River Estuary reported for 2009, 2010, and 2011 from baseline and public health monitoring under Interim Measure 15 of the KHSA (Watercourse 2011a, Watercourse 2011b, Watercourse 2012). The plots indicate that microcystin has been detected throughout the Klamath River system, but is most prevalent in Copco and Iron Gate reservoirs. During the summer and early fall in each of the years monitored, *Microcystis aeruginosa* cell densities and microcystin concentrations in Copco and Iron Gate reservoirs have reached and exceeded the guidelines for posting advisories in recreation water (SWRCB 2010). As a result of this monitoring, warning notices have been posted and advisories issued for the Project reservoirs and the Klamath River downstream of Iron Gate dam. During the annual public health monitoring, results of the monitoring of cell densities and microcystin concentrations in Copco and Iron Gate reservoirs are uploaded every one to two weeks on PacifiCorp's website at http://www.pacificorp.com/es/hydro/hl/kr.html# (under the "Water Quality Reports & Data" tab) as well as the Klamath Basin Monitoring Program website (www.kbmp.net). The public health monitoring data also indicate that exceedances of the guidelines have also occurred in the Klamath River, but they are less in magnitude and frequency than in Copco and Iron

Gate reservoirs (Figure 5.2-36, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013).

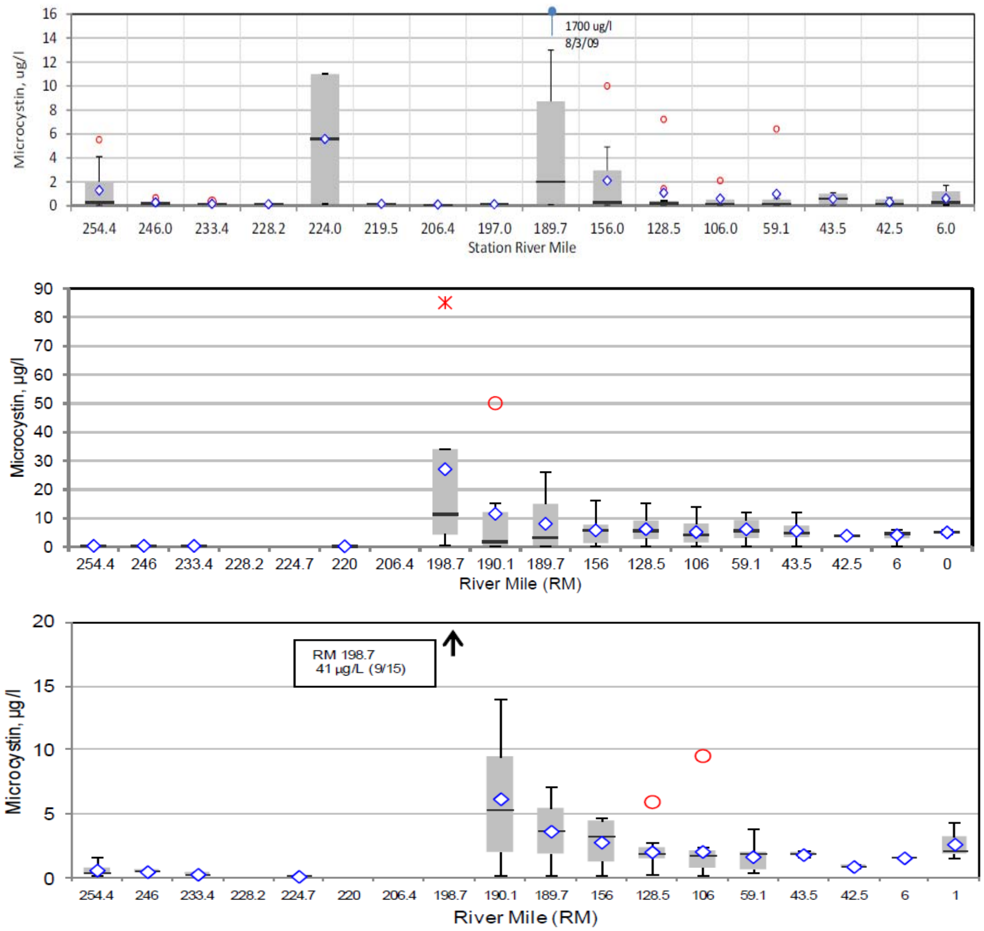


Figure 5.2-36. Box plots[37] of microcystin levels (µg/L) from Link River to the Klamath River Estuary[38] reported for 2009 (top plot), 2010 (middle plot), and 2011 (bottom plot) from public health monitoring under Interim Measure 15 of the KHSA (source: Watercourse 2011a, Watercourse 2011b, Watercourse 2012).

Inorganic and Organic Contaminants

In general, data on the presence of inorganic and organic contaminants in the Klamath River system, including the Project area, is sparse. Data are available from the California Surface Water Ambient Monitoring Program (SWAMP) from grab samples collected from 2001 through 2005 at eight sites in the Klamath River, including two sites in the Project vicinity: (1) at about Stateline (RM 208.5) and below

[37] A box plot (also known as a box and whisker diagram) is a basic graphing tool that displays the median, range, and distribution of a data set. The bottom of each box is the 25th percentile, the top of the box is the 75th percentile, and the line in the middle is the 50th percentile or median. The vertical lines above and below each box (the "whiskers") extend to maximum and minimum values to give additional information about the spread of data.

[38] The monitoring sites shown in the figure include RM 254.4: Link River dam, RM 246: Keno Reservoir at Miller Island, RM 233.4: Klamath River below Keno dam, RM 228.2: Klamath River above J.C. Boyle Dam, RM 224: Klamath River below J.C. Boyle Dam, RM 219.5: Klamath River below USGS Gage, RM 206.4: Klamath River near Stateline, RM 199: Copco Reservoir, RM 192: Iron Gate Reservoir, RM 189.7: Klamath River below Iron Gate Dam, RM 156: Klamath River at Walker Bridge Road, RM 128.5: Klamath River below Seiad Valley, RM 106: Klamath River near Happy Camp, RM 59.1: Klamath River at Orleans, RM 43.5: Klamath River at Weitchpec, RM 42.5: Klamath River below Weitchpec, RM 6: Klamath River near Klamath, and RM 0.5: Klamath River Estuary.

Iron Gate dam (RM 189) (NCRWQCB 2008). Grab sample analysis was performed on trace metals, pesticides and pesticide residues, and PCBs. Date were then evaluated to assess the number of exceedances and potential exceedances as compared to the applicable criteria, objectives, and standards (Basin Plan objectives, State of California DHS and EPA drinking water standards, State of California CTR and USEPA recommended criteria for freshwater protection of aquatic life, and USEPA recommended nutrient criteria for rivers and streams (NCRWQCB 2008).

Sample results from the two sites indicated that for the majority of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) concentrations were in compliance with water quality objectives. Aluminum concentrations ranged from 50.70 to 99.20 µg/L, with half the samples at levels that potentially exceeded EPA's continuous concentration for freshwater aquatic life protection (87 µg/L). Grab samples from Stateline included one detection of dichlorodiphenyldichloroethylene (DDE) and one detection of trans-nonachlor (NCRWQCB 2008). The Project does not use or produce inorganic and organic materials that would cause such detections.

In 2004 and 2005, Shannon & Wilson (2006) analyzed sediment cores from the Project reservoirs for contaminants, including acid volatile sulfides, metals, pesticides, chlorinated acid herbicides, PCBs, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), cyanide, and dioxins. No herbicides or PCBs were found above screening levels and only one sample exceeded Puget Sound Dredge Disposal Analysis screening levels for VOCs ethyl benzenes and total xylenes (Shannon & Wilson 2006). Cyanide was detected in some of the sediment cores, but was not found in toxic free cyanide form (HCN or CN-), and is not likely to be bioavailable or result in adverse effects on fish and other aquatic biota. Dioxin was detected in three sediment cores samples from the Project Reservoirs, but at levels within the range of natural background dioxin concentrations (2–5 ppt) for non-source-impacted sediments in the western U.S. (Shannon & Wilson 2006). The dioxin levels also did not exceed Puget Sound Dredged Disposal Analysis screening levels, and were an order of magnitude below EPA effects-based ecological receptors thresholds for fish, mammals, and birds (Shannon & Wilson 2006).

As part of the Secretarial Determination studies, additional sediment evaluation in the Project reservoirs was undertaken during 2009–2011. That expanded the number of sediment cores and the analytes examined, including chemicals likely to bioaccumulate, and included biological and elutriate tests (Reclamation 2010). A total of 501 analytes were quantified across the samples, including metals, poly-aromatic hydrocarbons (PAHs), PCBs, pesticides/herbicides, phthalates, VOCs, SVOCs, dioxins, furans, and polybrominated diphenyl ethers (PBDEs) (i.e., flame retardants). Samples were analyzed for sediment chemistry and elutriate (pore water) chemistry, and bioassays and bioaccumulation studies were conducted on the sediment and elutriate using fish and invertebrate national benchmark toxicity species.

Overall, there were relatively few chemicals in sediment from the Project reservoirs identified as chemicals of potential concern or that are notably contaminated based on comparison to thresholds developed through regional and state efforts such as the Sediment Evaluation Framework (SEF) for the Pacific Northwest Oregon and ODEQ bioaccumulation screening level values (CDM 2011). Toxicity equivalent quotients (TEQs) were calculated for dioxin, furan, and dioxin-like PCBs in reservoir sediment samples to evaluate potential adverse effects from exposure to dioxin, furan, and dioxin-like PCBs. The calculated TEQs are generally within the range of regional background values and have limited potential for adverse effects for fish exposed to reservoir sediments (CDM 2011).

Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species. Collectively, the elutriate chemistry and elutriate toxicity did not identify toxicity by location, representative organism, or conditions (CDM 2011). Overall, the Secretarial Determination sediment studies concluded that sediment quality of reservoir sediments does not appear to be highly contaminated and generally reflects regional background conditions (Reclamation 2010, CDM 2011).

As part of the FLA, PacifiCorp conducted a study to assess whether toxic substances are present in the tissues of fish present in the Project reservoirs (PacifiCorp 2004h). Details of the study were presented in a technical report titled "Screening Level Determination of Chemical Contaminants in Fish Tissue in Selected Project Reservoirs" (contained in PacifiCorp 2004h). Fish samples were collected from each of the Project reservoirs and Upper Klamath Lake. Largemouth bass (*Micropterus salmoides*) was the primary target species, but black bullhead catfish (*Ameiurus melas*) were used for samples from Keno reservoir and Upper Klamath Lake, where largemouth bass were unavailable. These species were chosen because they are the most sought after game species in the reservoirs, and consequently represent the potentially greatest risk related to consumption.

Fish tissue samples were collected and analyzed for selected metals, organochlorine (pesticide) compounds, and PCBs. Metals analysis included arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc. Largemouth bass (Micropterus salmoides) was the primary target species, but black bullhead catfish (Ameiurus melas) were used for samples from Keno reservoir and Upper Klamath Lake, where few largemouth bass were captured.

All of the measured fish tissue values for total mercury were well below the screening values for protection of human health based on EPA (2000). Values for total mercury measured in largemouth bass from Iron Gate reservoir and Copco reservoir were slightly above the screening value for protection of wildlife obtained from MacDonald (1994). All other measured mercury values were below the screening value for wildlife. Arsenic was detected in several samples, but no value exceeded the method reporting limit, and all were below the toxicity screening value for recreational fishers.

Fish tissue samples were analyzed for 41 pesticides and pesticide byproducts. Only two pesticide residues, DDE and hexachlorobenzene, were detected in any sample, and none of the detected levels of these two residues exceeded the human health screening values. Some of the fish tissue samples from Upper Klamath Lake and the Project reservoir exceeded the suggested wildlife screening value for total DDTs, of which DDE is a component. PCBs were detected in all samples but were less than the screening value for recreational fishers in all samples. Total PCB values in all the samples analyzed for this study were less than the toxicity screening value for protection of wildlife.

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.

5.2.14.3 Project Contribution

Abundant algal growth, such as occurs seasonally in Copco and Iron Gate reservoirs, includes cyanobacteria, notably *Microcystis*, which produce the toxin microcystin. Copco and Iron Gate reservoirs provide lacustrine conditions where these cyanobacteria grow. However, the abundant algae growth in the reservoirs is primarily caused by the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake. In particular, the increased *Microcystis* blooms that have occurred in recent years in the Project reservoirs are: (1) consistent with the elevated levels of inorganic nitrogen (e.g., ammonia, nitrate) and organic matter in influent waters to the reservoirs; and (2) coincident with increases in nitrogen in the outflow from Upper Klamath Lake (such as seen in Figure 4.2-18 in Section 4.2). In addition, *Microcystis* blooms in the Klamath Basin and the Project reservoirs are part of a rising incidence of toxin-producing cyanobacteria elsewhere in California and the U.S. (Lehman et al. 2013, CDPH 2013, Oregon State University 2013).

Regarding inorganic and organic contaminants, the analysis of waters and sediments from the Project area (as described above) does not indicate a problem with toxic substances. Most compounds analyzed for were below the detection limit of the analytical methodology, below relevant screening levels, or within the range of regional background conditions. The Project does not use or produce toxic substances to the waters of the Klamath River.

Regarding potentially-toxic un-ionized ammonia, 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 upstream sources, notable Upper Klamath Lake.

5.2.14.4 Proposed Measures

As described above, Copco and Iron Gate reservoirs provide lacustrine conditions where cyanobacteria grow. However, the Project does not cause or contribute to the large loads of nutrients flowing into the Project area from upstream sources, particularly Upper Klamath Lake, that are the primary cause of the high phytoplankton production and eutrophic conditions in the Project reservoirs. 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. These actions and activities include: (1) constructed wetlands conceptual design and implementation planning; (2) further evaluation of tailrace aeration and oxygenation systems; (3) design and implementation planning of reservoir oxygenation systems; (4) evaluation of epilimnion (surface water) mixing and circulation; (5) further evaluation of selective withdrawal and intake control; (6) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoirs; and (7) additional testing and controlled applications of SCP algaecide to treat localized areas (e.g., coves, embayments) in the reservoirs. It is anticipated that these RMP actions and activities will have the effect of reducing nutrients and algae growth, and thus reduce production and concentrations of microcystin toxin within the reservoirs and in downstream releases to the river.

PacifiCorp also proposes to continue to fund and implement a baseline water quality monitoring program, including the public health monitoring component to provide timely information that can be used to inform public health agencies if cyanobacteria and toxins of concern are present, and to determine the need to post warning notices and issue advisories for the Project reservoirs and/or areas of the Klamath River. As a result of this monitoring, warning notices will be posted and advisories issued for the Project reservoirs and the Klamath River as necessary.

The Project does not use or produce other contaminants and potential toxins. Consequently, no specific new measures are proposed with respect to other contaminants and potentially-toxic substances. PacifiCorp adheres to material storage, control, and maintenance procedures to prevent or reduce the potential for accidental release of potential contaminants. In addition, spill prevention and response plans are maintained at Project facilities in order to facilitate rapid response in the unlikely event of an accidental release to Project waters.

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

Conditions regarding the presence of pesticides in the waters and sediments in the vicinity of the Project are discussed in Section 5.2.14.2 above.

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 specific new measures are proposed with respect to pesticides, although PacifiCorp may continue to further evaluate the potential for environmentally-safe hydrogen peroxide-based algaecide (sodium carbonate peroxyhydrate, or SCP) as a potential tool for improving reservoir water quality conditions as within the context of the Reservoir Management Plan, as described in Appendix B. The use of SCP does not result in concentrations of pesticides that adversely affect beneficial uses as the degradation byproducts of SCP-based algaecides are oxygen and water.

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 µmhos (at 77ºF) – 90 percent exceedance
	275 µmhos (at 77ºF) – 50 percent exceedance
Below Iron Gate dam	450 µmhos (at 77ºF) – 90 percent exceedance
	275 µmhos (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 µmhos and 97.2 percent have been below 275 µmhos.

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 [39]	**50% Upper Limit** [40]
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 [41]	0.2 [42]
Other Streams	0.1 [43]	0.0 [44]
Groundwaters	0.1	0.0

[39] "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.

[40] "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.

[41] Does not apply to estuarine areas. North Coast Basin Plan, at 3-7.00.

[42] *Id.*

[43] *Id.*

[44] *Id.*

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.

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 it 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 effects 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 FLA 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.

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APPENDIX A
Water Temperature Modeling Results: 2002-2004 Tables

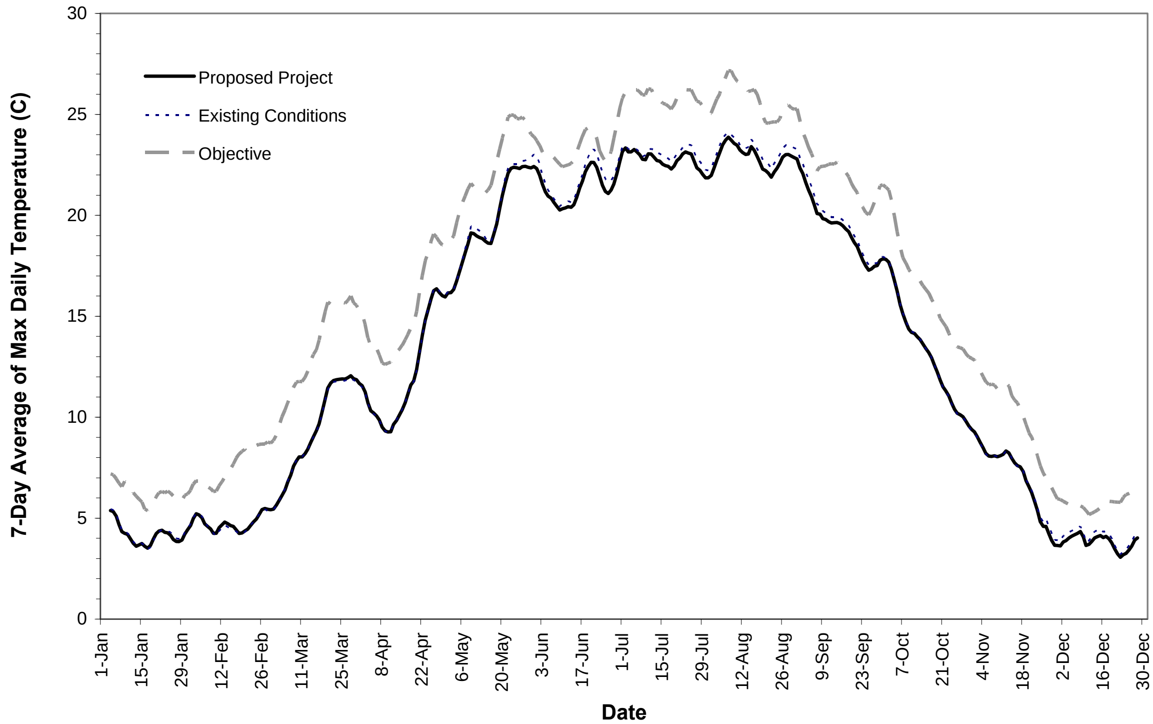

Figure 1. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

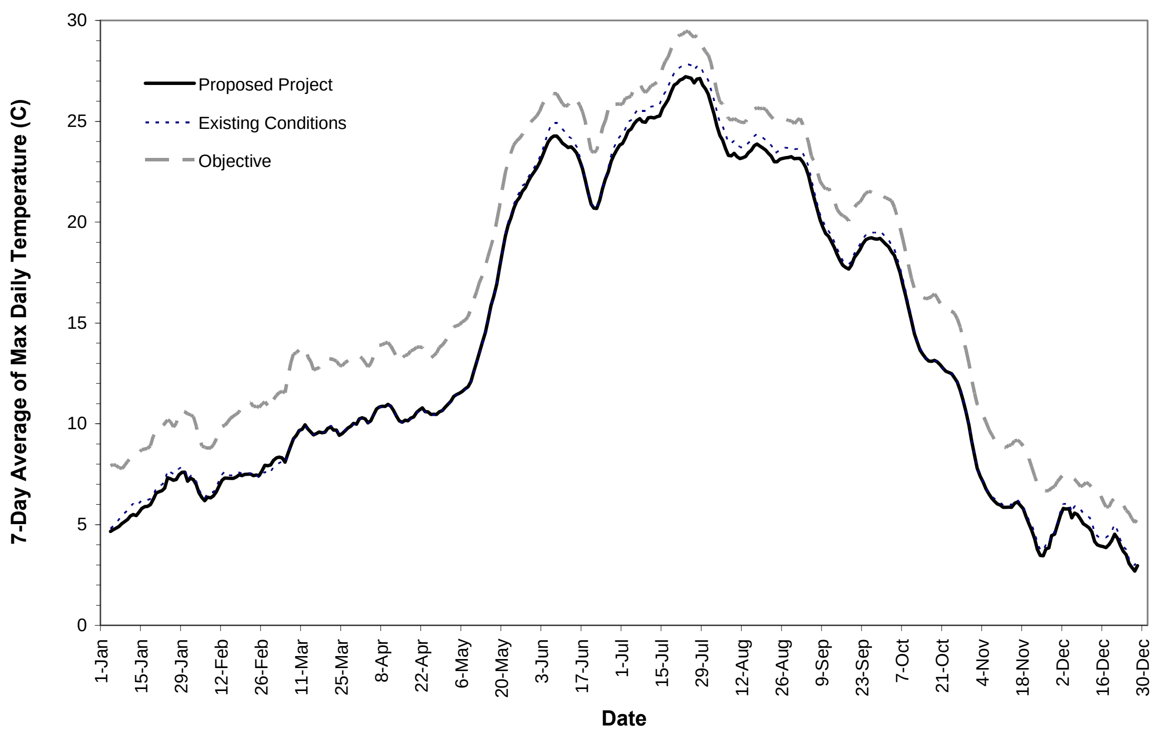

Figure 2. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

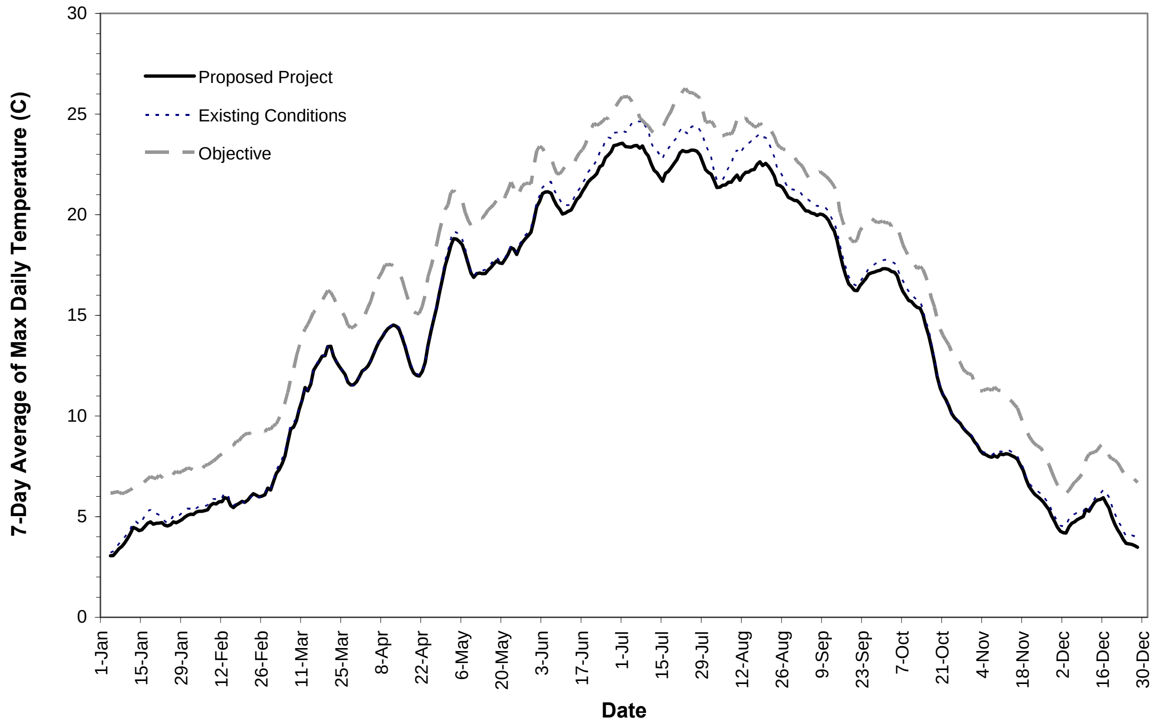

Figure 3. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Stateline (RM 209.2) compared to the California temperature objective (based on model simulations).

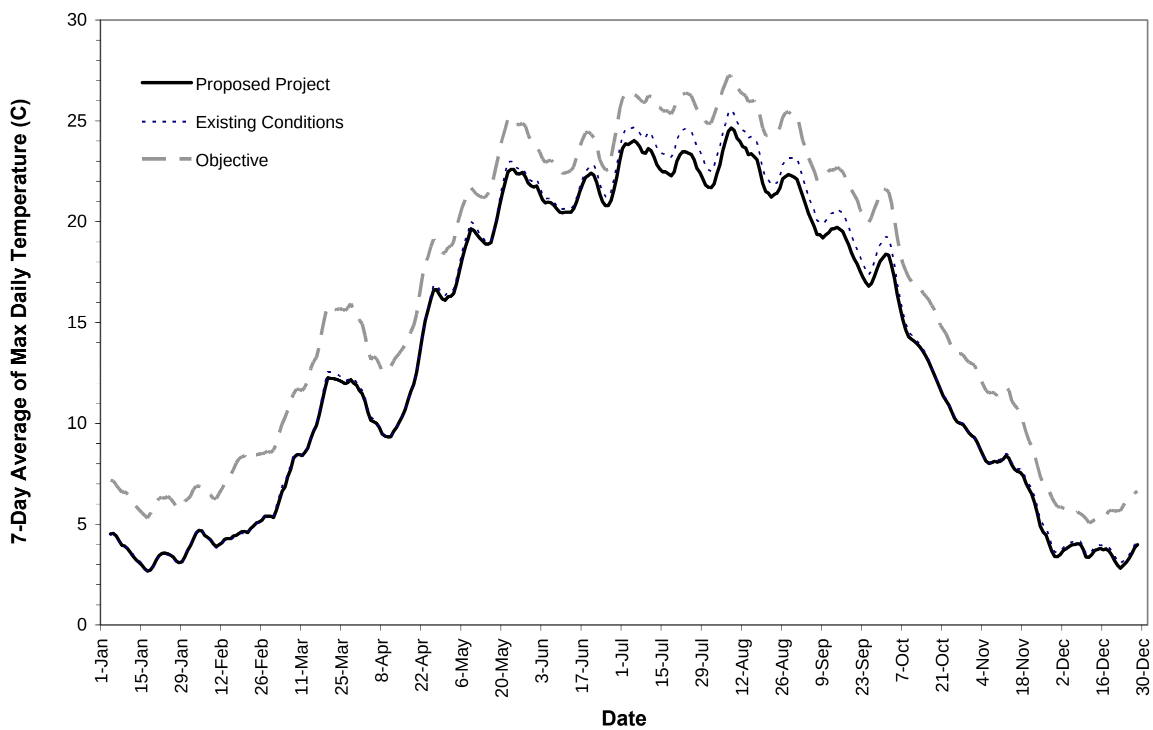

Figure 4. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

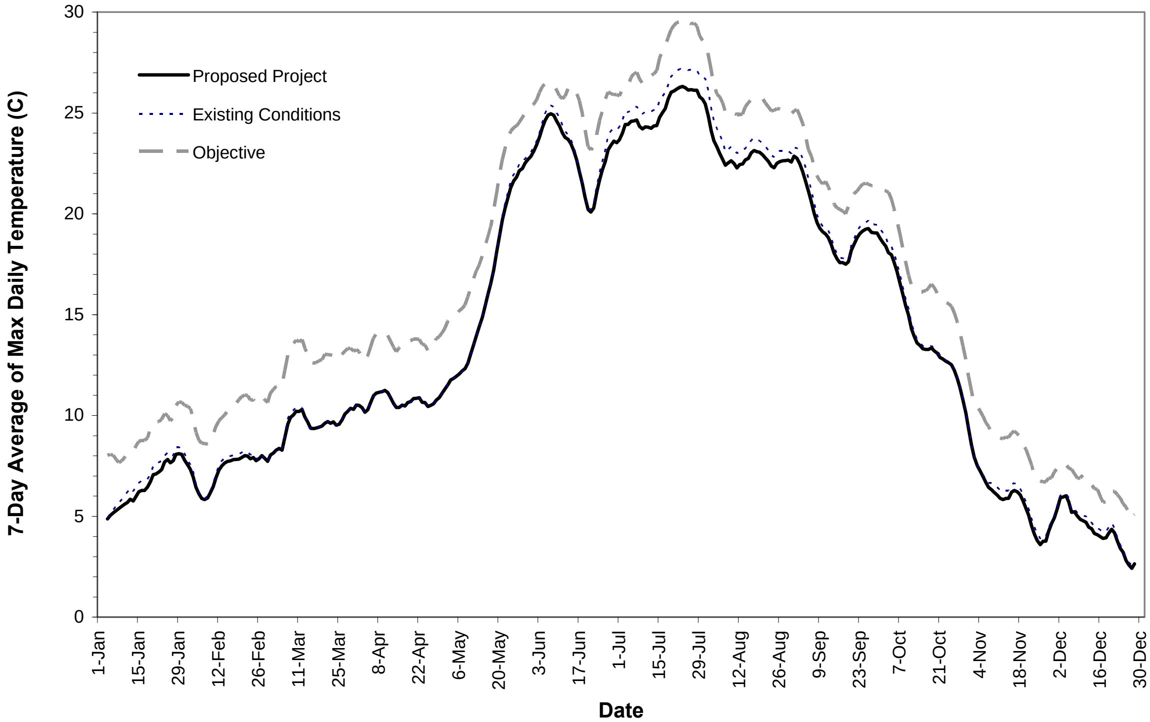

Figure 5. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

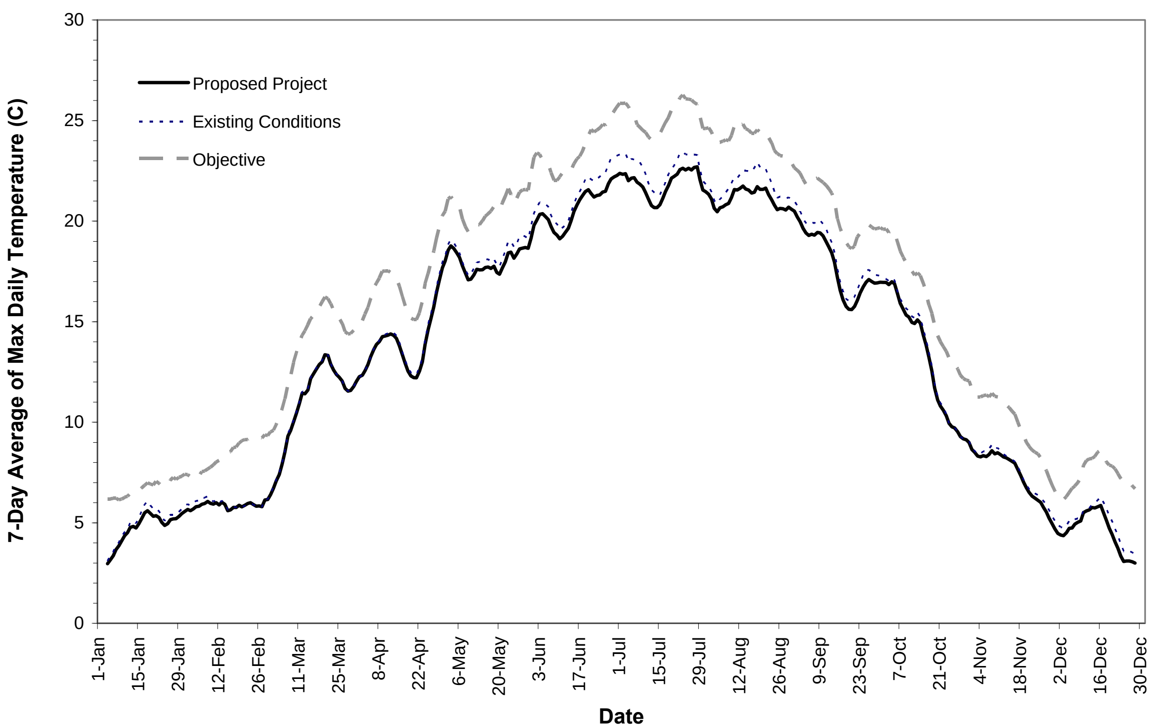

Figure 6. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River above Copco reservoir (RM 203.6) compared to the California temperature objective (based on model simulations).

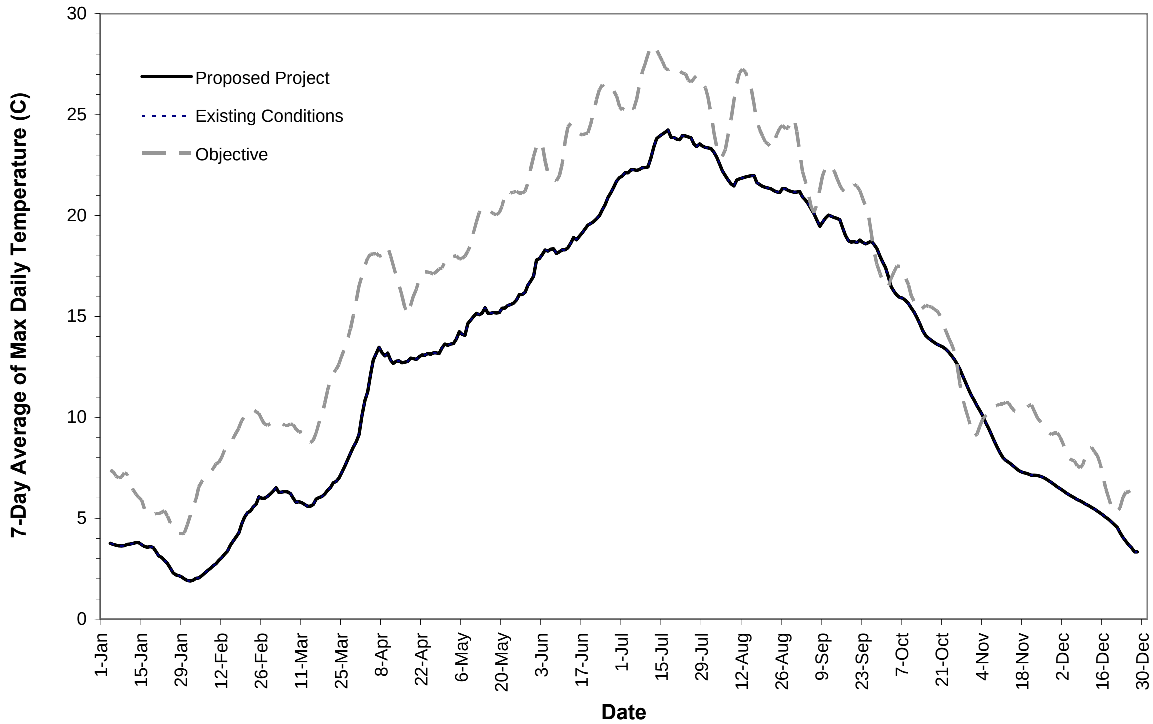

Figure 7. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

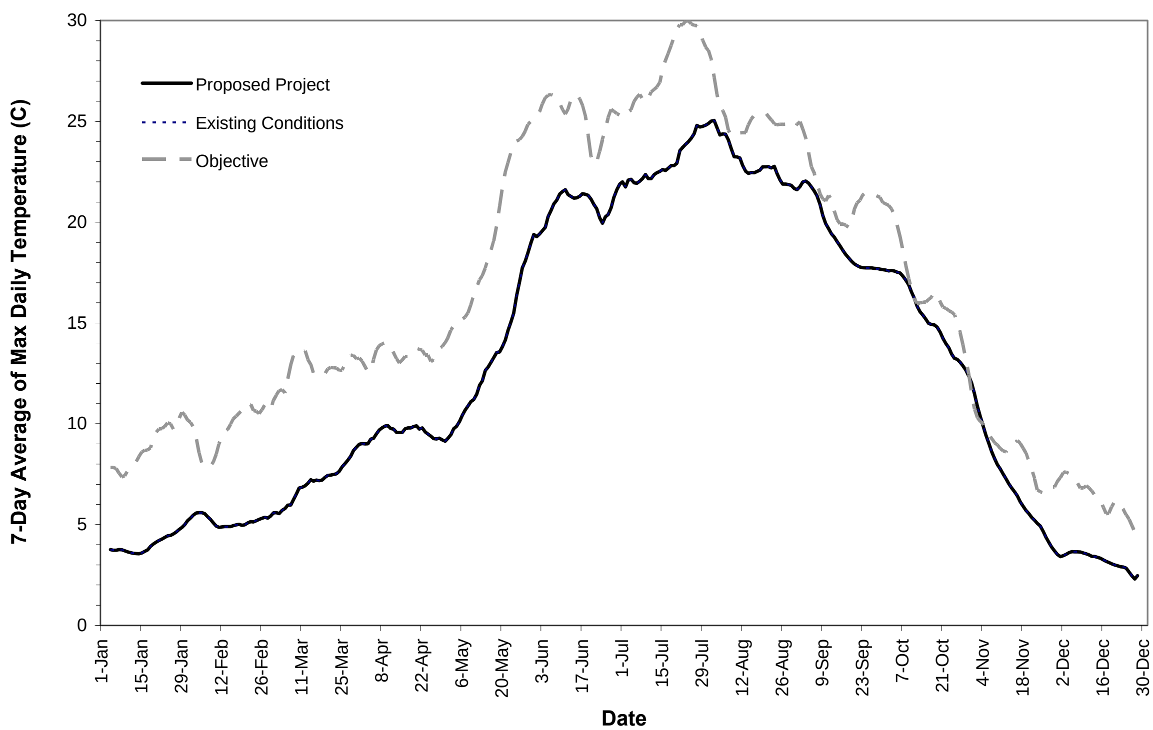

Figure 8. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

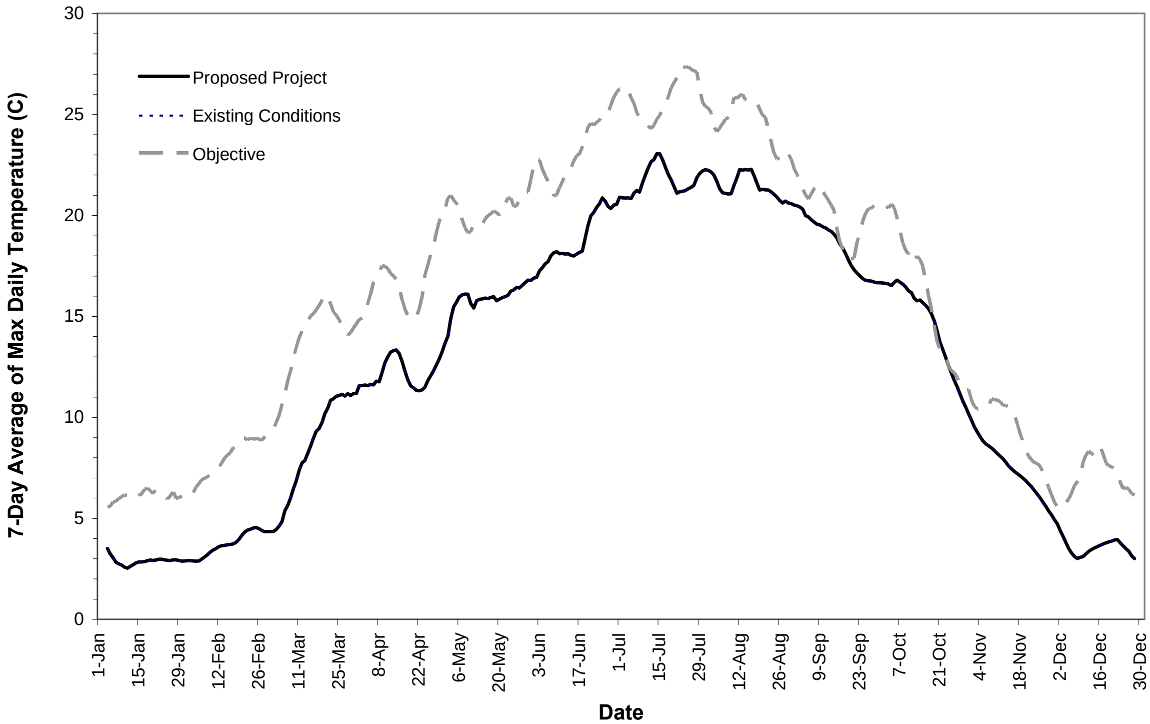

Figure 9. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Copco No. 1 dam (RM 198.6) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

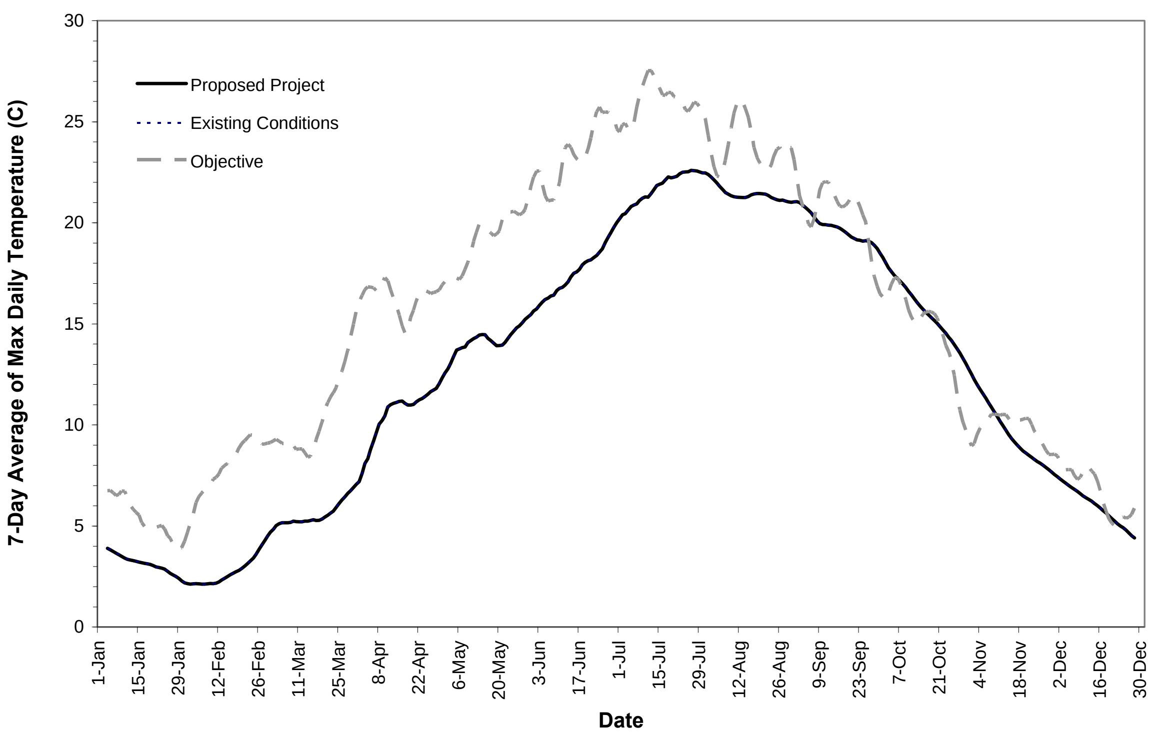

Figure 10. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

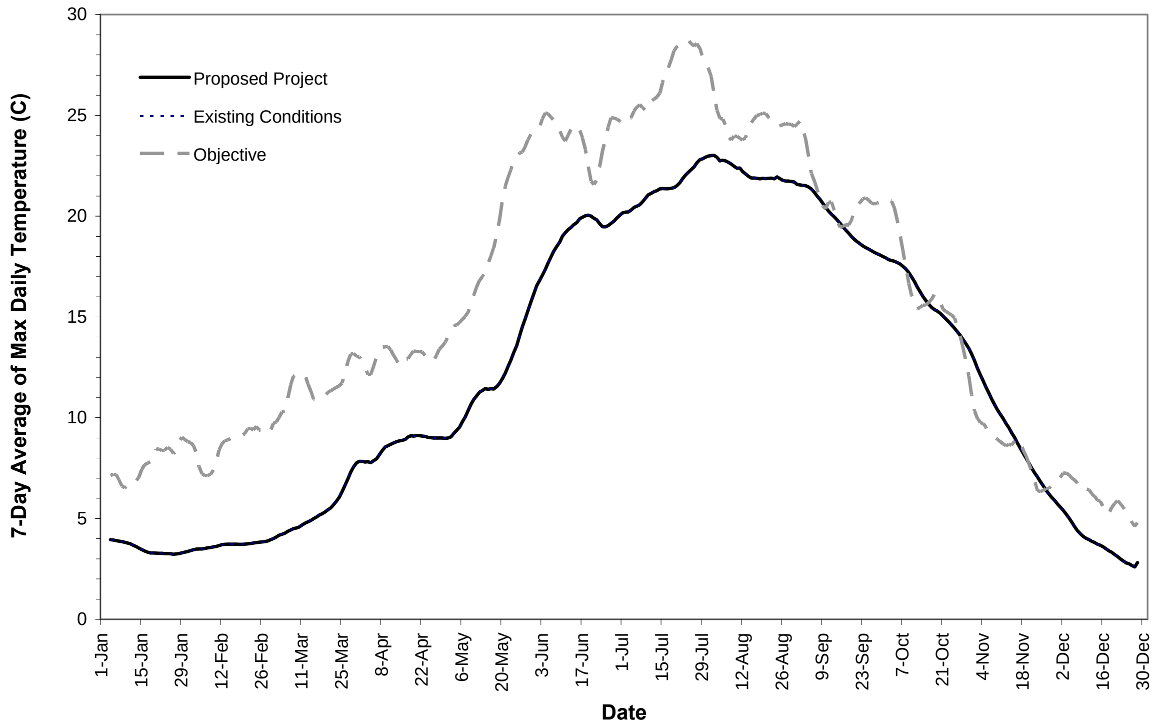

Figure 11. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

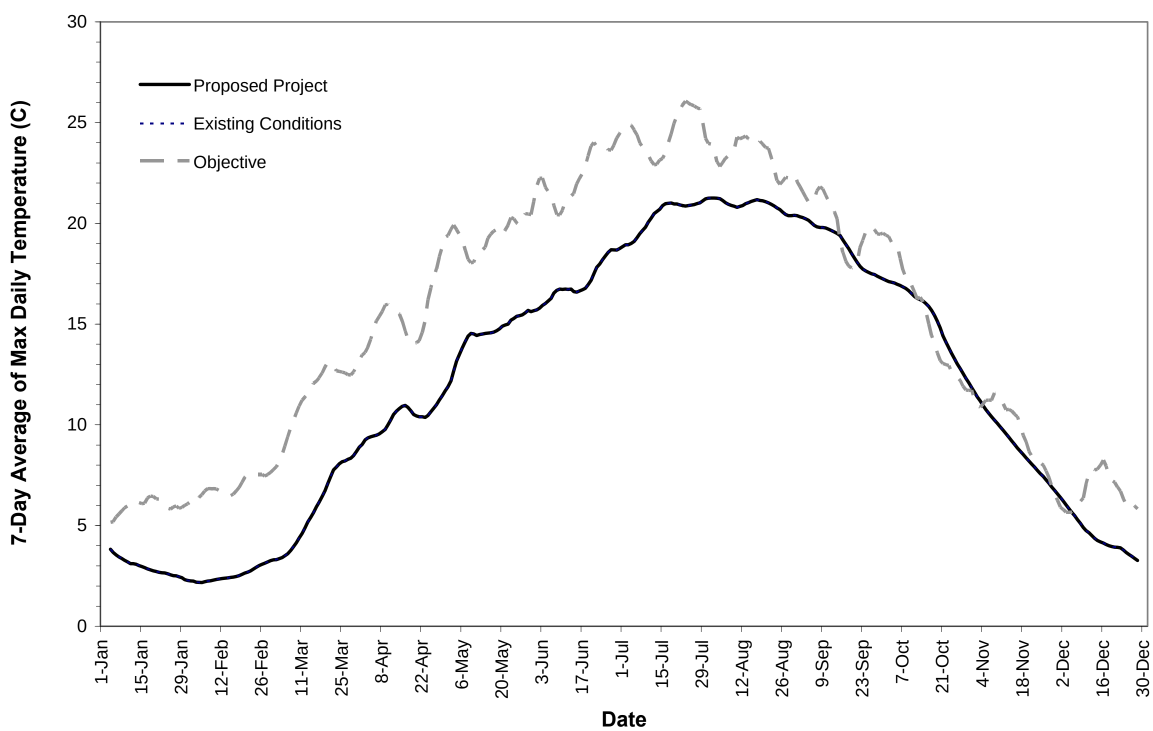

Figure 12. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Iron Gate dam (RM 190.5) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

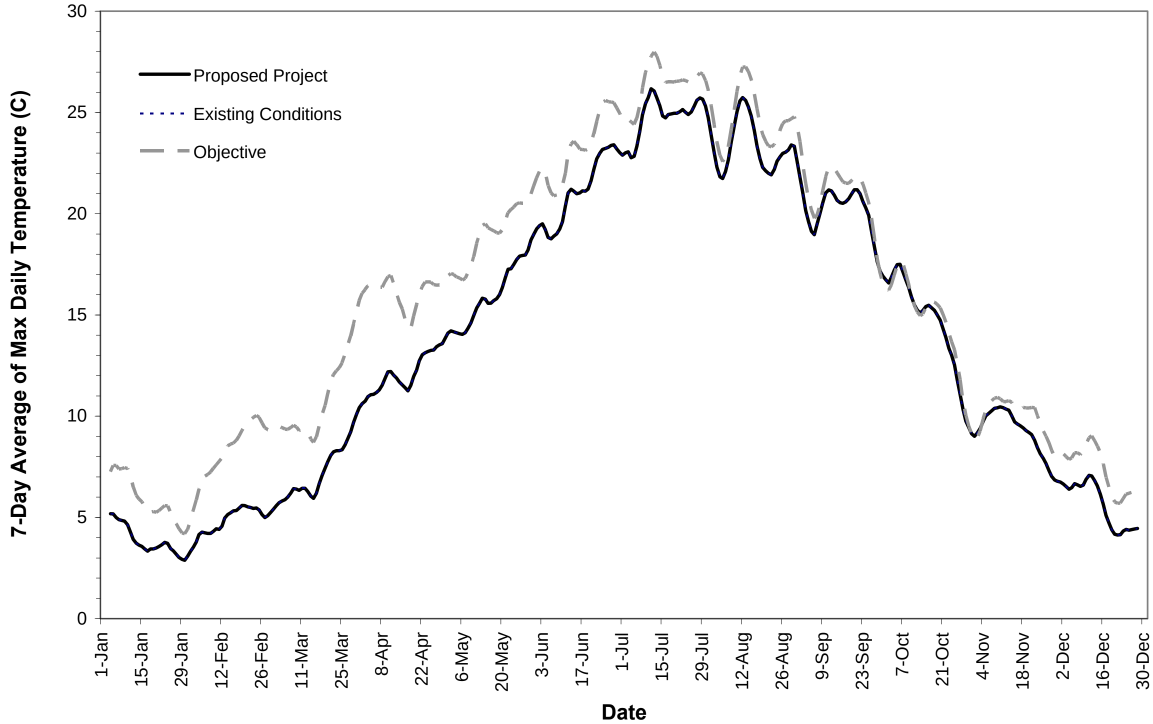

Figure 13. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

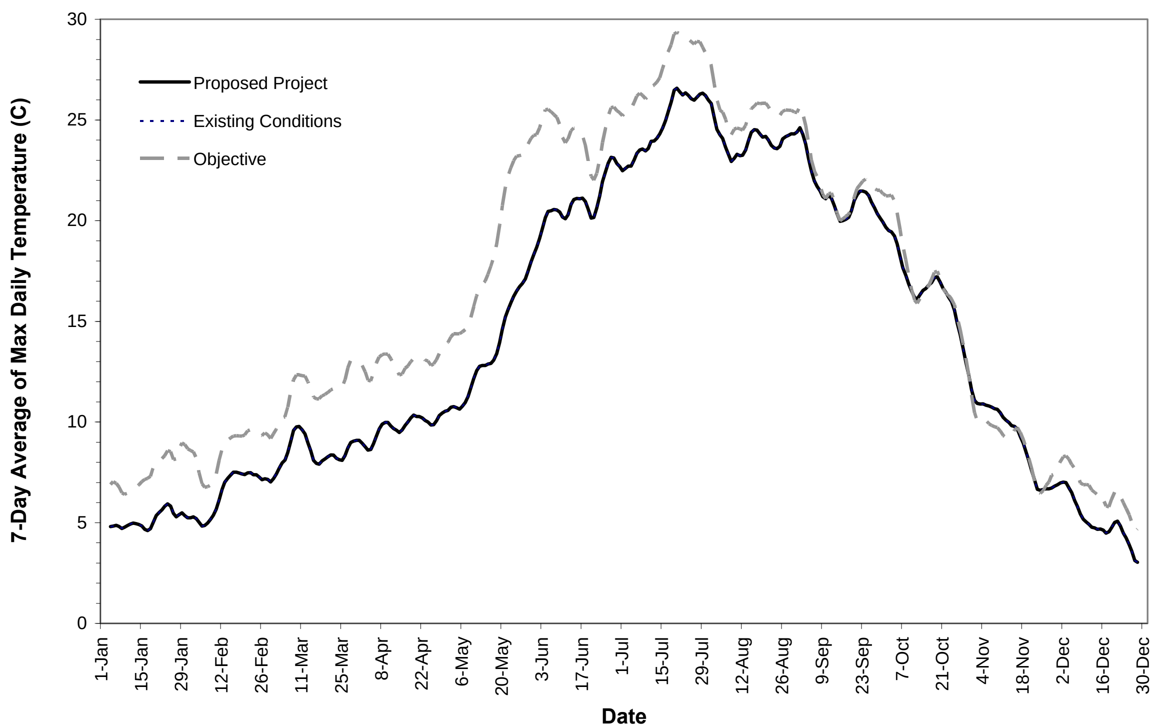

Figure 14. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

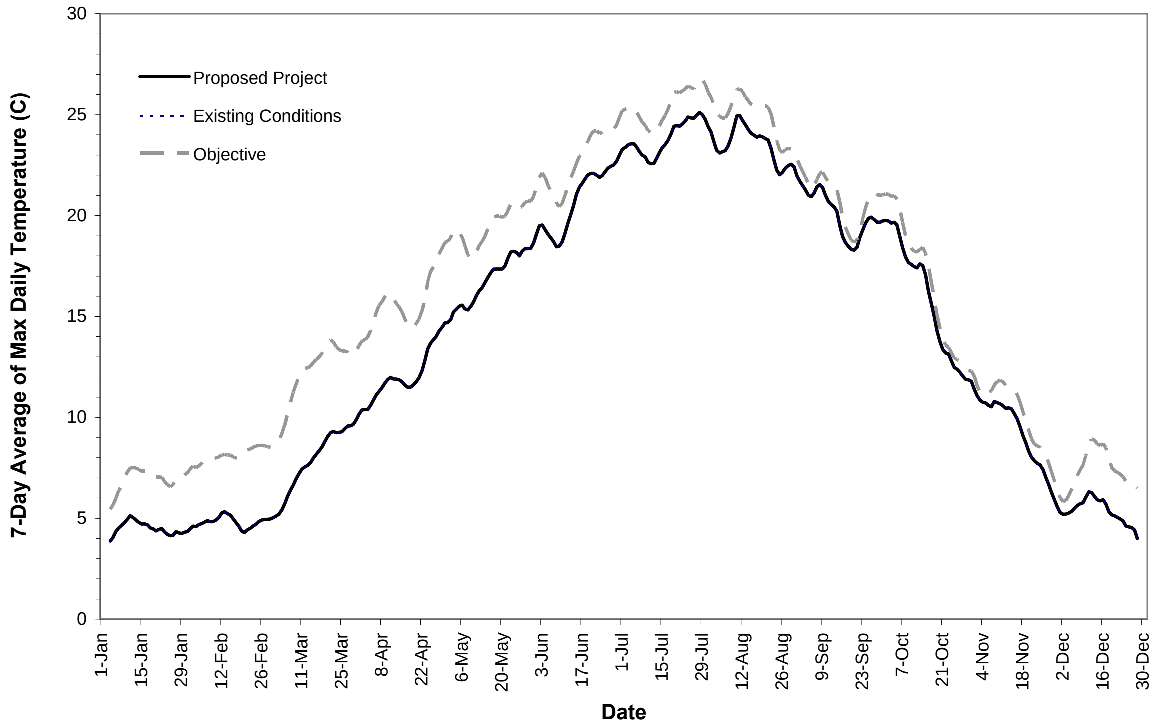

Figure 15. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at the Scott River (RM 144) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

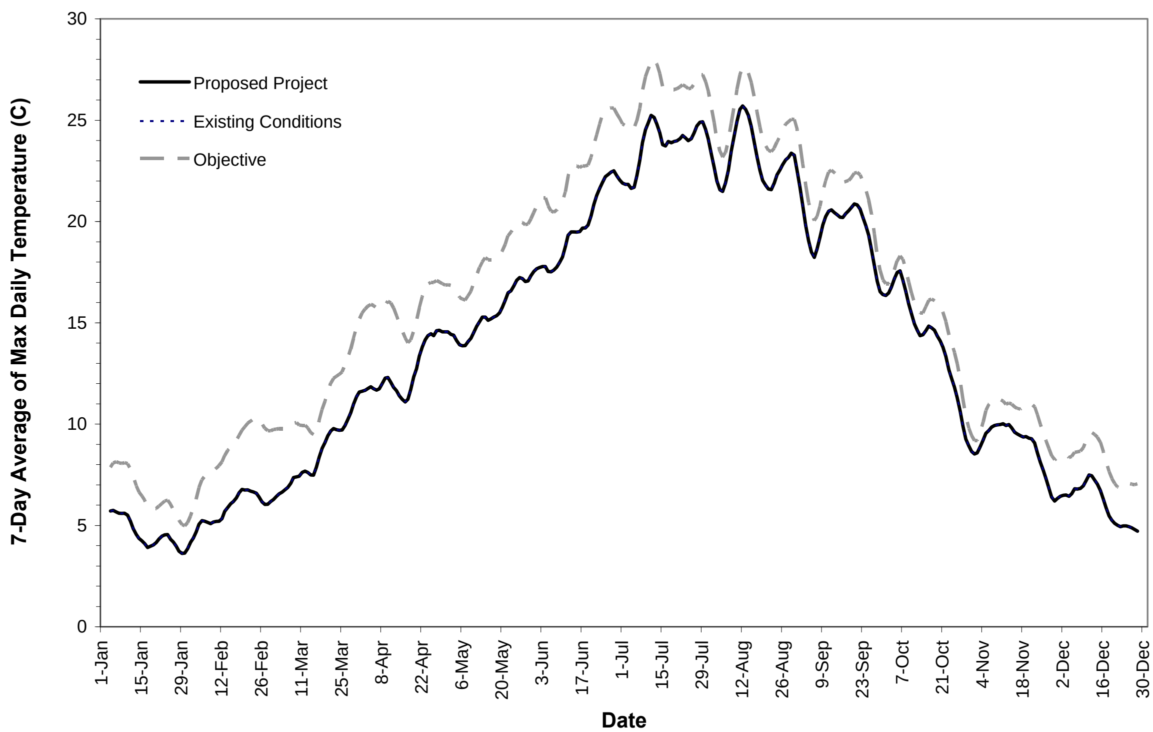

Figure 16. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

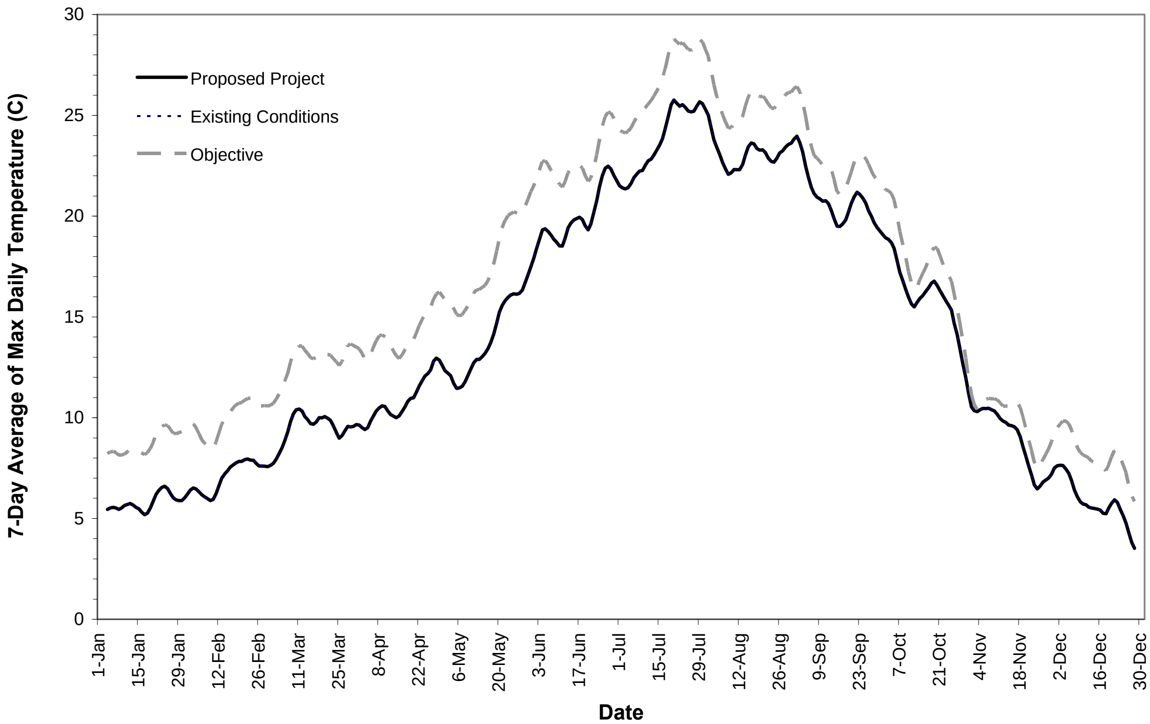

Figure 17. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

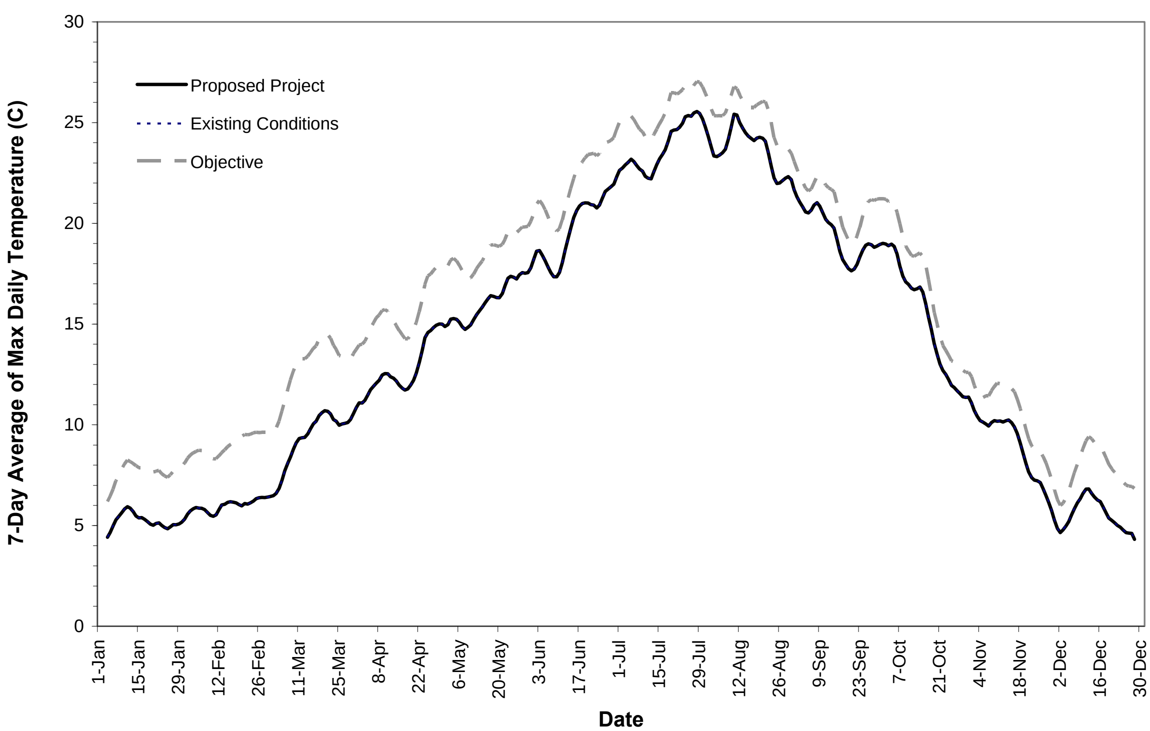

Figure 18. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Seiad Valley (RM 129) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

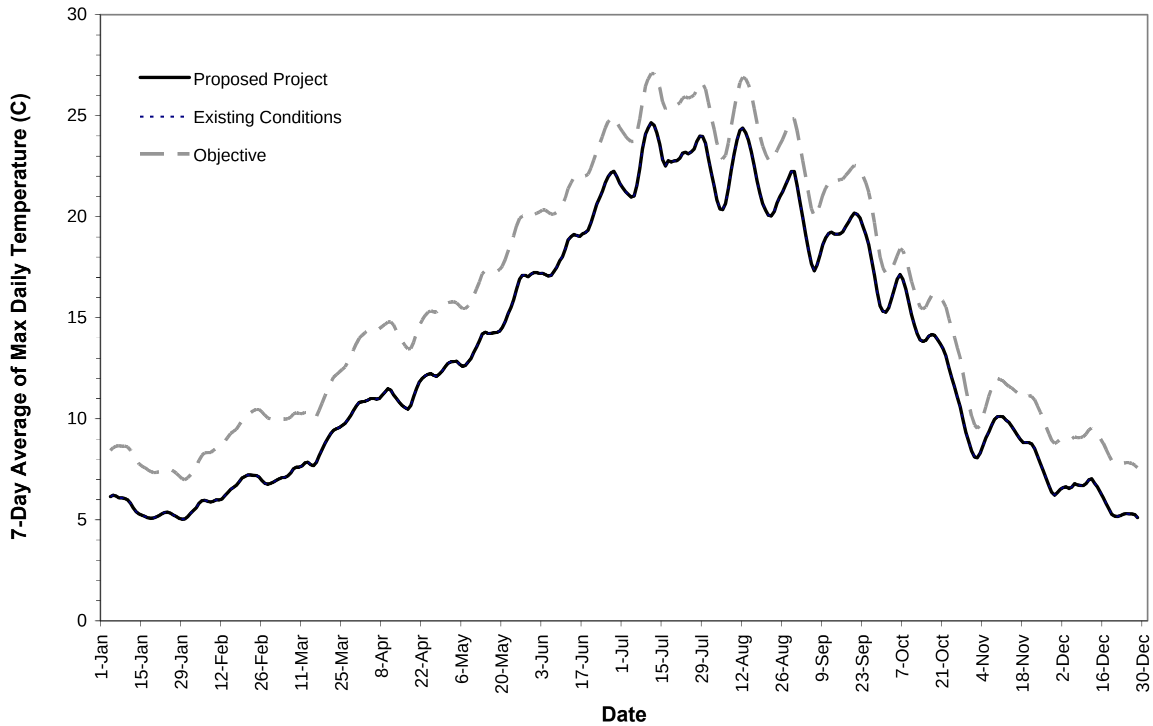

Figure 19. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

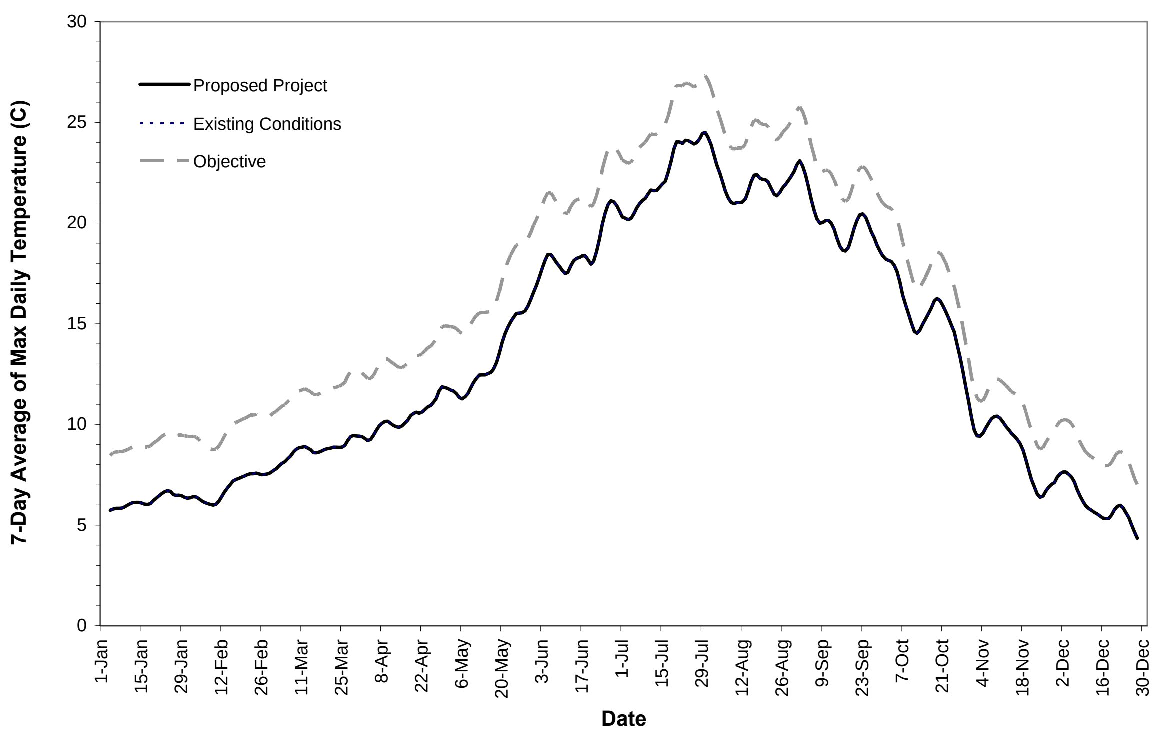

Figure 20. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

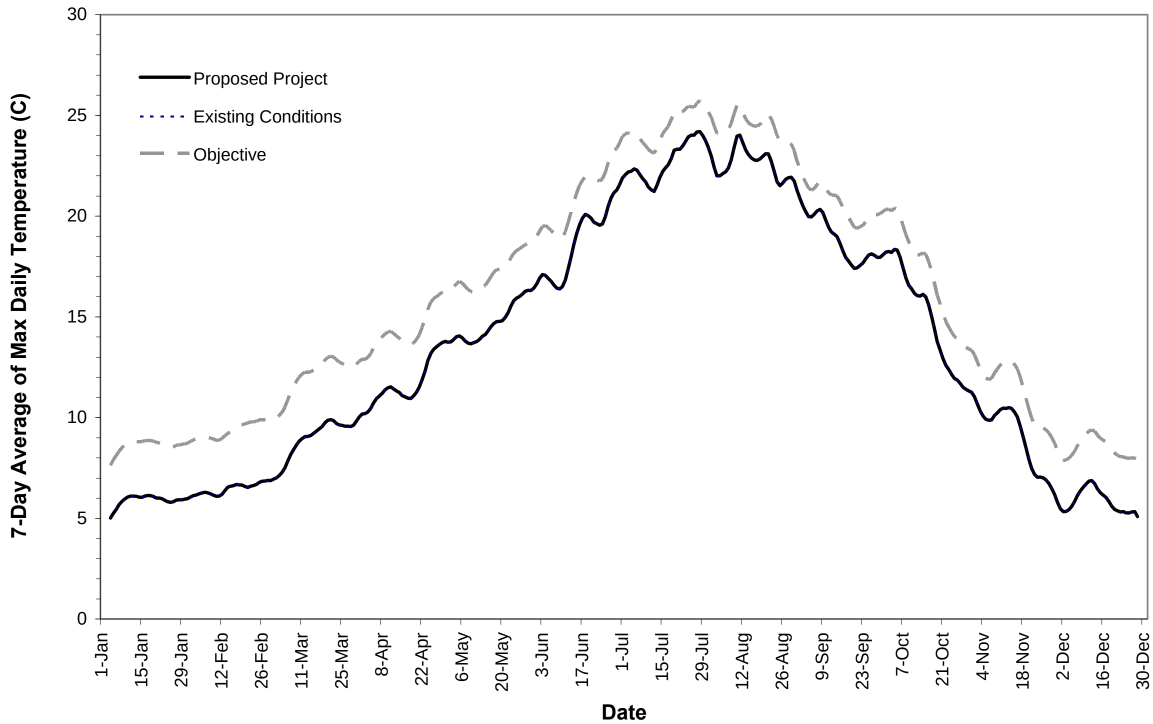

Figure 21. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at the Salmon River (RM 66.9) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

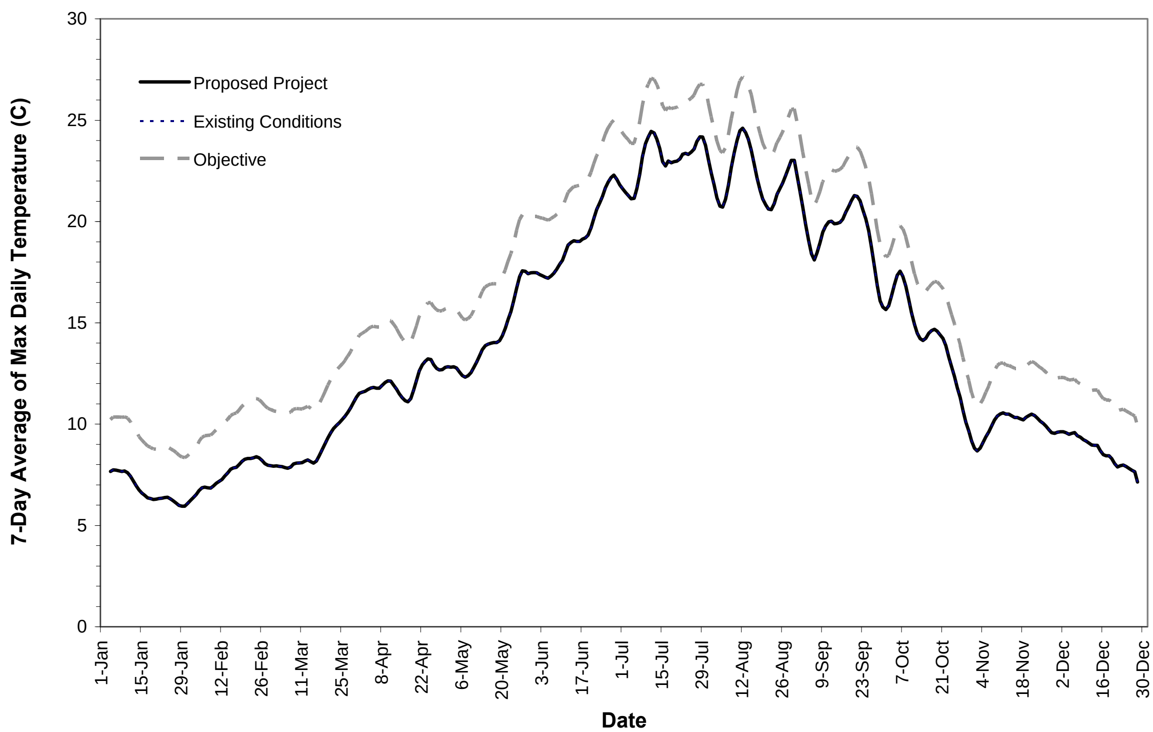

Figure 22. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2002 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

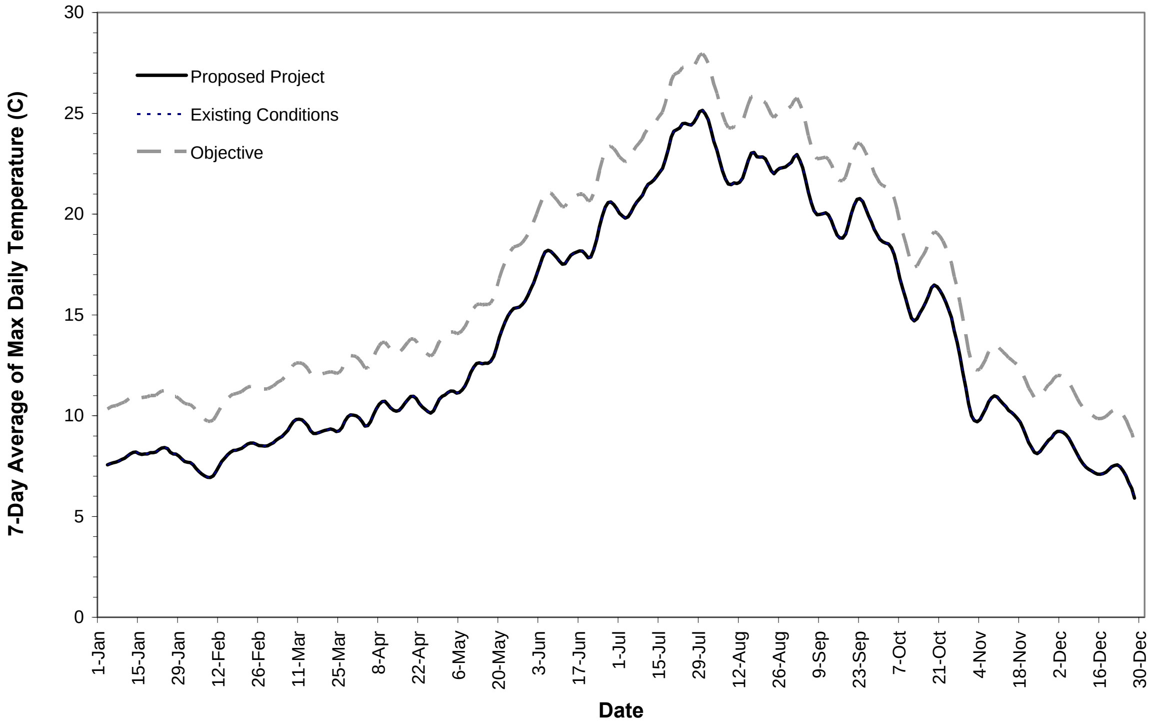

Figure 23. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2003 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

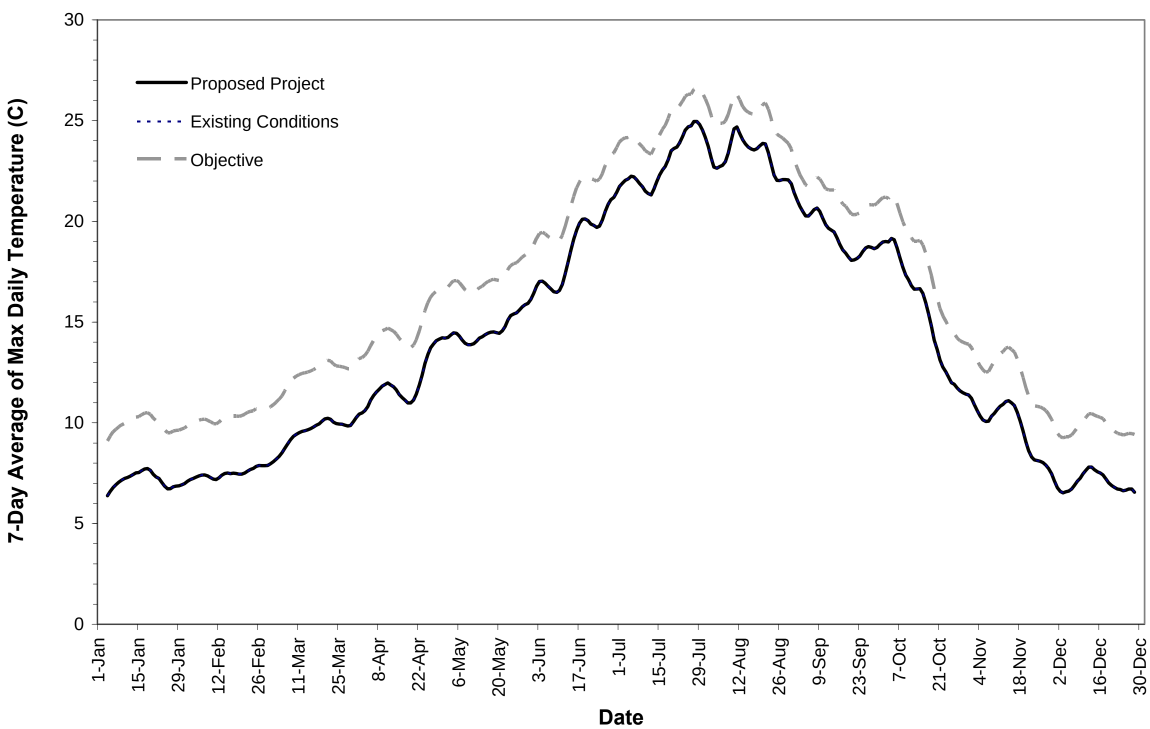

Figure 24. Time-series of the 7-day average of maximum water temperature (in degrees C) for the year 2004 in the Klamath River at Turwar (RM 5.3) compared to the California temperature objective (based on model simulations). Proposed Project and Existing Conditions are coincident.

APPENDIX B

Reservoir Management Plan for Copco and Iron Gate Reservoirs (Revision: August 2014)

APPENDIX B
RESERVOIR MANAGEMENT PLAN FOR COPCO AND IRON GATE RESERVOIRS
(REVISION: AUGUST 2014)

B.1 INTRODUCTION

PacifiCorp is implementing this Reservoir Management Plan (RMP) to improve water quality in Copco and Iron Gate reservoirs. This RMP is attached as Appendix B to PacifiCorp's application to the State Water Resources Control Board (State Water Board) for Section 401 Water Quality Certification (WQC) for the Klamath Hydroelectric Project (Project). The RMP evaluates the effectiveness and feasibility of several technologies and measures to control and enhance water quality conditions in Copco and Iron Gate reservoirs. Based on the approach outlined in this RMP, decisions regarding selection and implementation of specific technologies and measures will be made by PacifiCorp in consultation with the State Water Board.

This RMP is a revised version of a similar plan developed in March 2008 (PacifiCorp 2008b). This revised version of the RMP contains updated information on the process PacifiCorp is following to evaluate, test, design, implement, and monitor water quality measures at Copco and Iron Gate reservoirs. Reservoir management actions and activities currently planned by PacifiCorp are described in Section B.3 of this RMP, 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 RMP.

B.2 BACKGROUND ON RESERVOIR CONDITIONS AND MANAGEMENT APPROACH

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. The lake has a history of nutrient enrichment problems and is currently hypereutrophic (Wee and Herrick 2005). The lake's outlet at Link River dam (RM 254) contributes large amounts of nutrients and organic material to the Klamath River (Sullivan et al. 2011, Sullivan et al. 2009, ODEQ 2010, Deas and Vaughn 2006, PacifiCorp 2006, ODEQ 2002). Management of these upstream sources is unaffected by and beyond the control of PacifiCorp's Project operations. As such, this RMP does not (and cannot) directly address the upstream loads of nutrients and organic matter that result in algae blooms, low dissolved oxygen levels, and high pH levels in Copco and Iron Gate reservoirs. Control of the large inflow loads of nutrients and organic matter from upstream sources is most appropriately addressed through controls on those sources, primarily upstream in Oregon, for example through the implementation of appropriate Total Maximum Daily Loads (TMDLs) developed by the Oregon Department of Environmental Quality (ODEQ).

Actions to be implemented through this RMP are aimed at improving reservoir water quality conditions notwithstanding the upstream loads of nutrients and organic matter that PacifiCorp cannot control. The RMP will also help to improve water quality in the Klamath River below the Project reservoirs. Therefore, the measures implemented under this RMP complement the system-wide TMDLs by improving water quality until nutrient load reductions can be realized through implementation of appropriate TMDLs.

As a result of upstream organic and nutrient loads, Copco and Iron Gate reservoirs experience high primary production, including blue-green algae blooms, primarily during the June-October period. Recent systematic sampling by PacifiCorp and others have identified blooms of the toxin-producing blue-green algae species *Microcystis aeruginosa* in Copco and Iron Gate reservoirs, as well as at other locations throughout the Klamath Basin, including upstream in Upper Klamath Lake and Agency

Lake (PacifiCorp 2008a, PacifiCorp 2008b, Raymond 2009a, Raymond 2009b, Raymond 2010a, Raymond 2010b, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013, Hoilman et al. 2008, Mioni et al. 2011, Caldwell-Eldridge et al. 2012, Eldridge et al. 2012). Similar increases in concentrations of *Microcystis* have been identified in numerous other water bodies in California, including the Eel River, Van Duzen River, Clear Lake, Lake Elsinore, and San Francisco Bay Delta, among others (Lehman et al. 2013, CDPH 2013), and in Oregon (ODHS 2014, OHA 2012).

The combination of organic matter from upstream sources, coupled with respiration and decay of algae biomass in the Project reservoirs impart an oxygen demand that contributes to low dissolved oxygen conditions in the hypolimnia of the reservoirs, primarily during the June-October period (PacifiCorp 2008b, PacifiCorp 2006, PacifiCorp 2004a, PacifiCorp 2004b). 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 surface waters of the reservoirs.

The intent of this RMP is to implement actions that will improve water quality conditions related to the primary production, respiration, and decay processes within the reservoirs and associated oxygen demands and nutrients in inflowing waters (and attendant effects on summertime algae blooms, dissolved oxygen and pH conditions)[45]. The actions considered in this RMP consist of proven techniques for lake and reservoir water quality management, such as described by Cooke and Kennedy (1989), Cooke et al. (2005), and Holdren et al. (2001). Such techniques have resulted in appreciable water quality improvements in other water bodies (see the above-cited references).

As explained below, PacifiCorp has been evaluating a number of water quality management techniques for application in Copco and Iron Gate reservoirs. These comprise techniques to control nutrients, algae, dissolved oxygen and pH, including: (1) constructed treatment wetlands; (2) reservoir and tailrace aeration and oxygenation systems; (3) epilimnion (surface water) mixing and circulation; (4) selective withdrawal and intake control; (5) reservoir drawdown and fluctuation; and (6) algaecide treatment. This RMP 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 appropriate TMDLs to control and reduce nutrient loads upstream of the Project, are expected to provide appreciable and sustained water quality enhancements in and below Copco and Iron Gate reservoirs.

B.3 OVERVIEW OF TECHNIQUES USED FOR WATER QUALITY IMPROVEMENTS IN RESERVOIRS AND THEIR APPLICABILITY TO COPCO AND IRON GATE RESERVOIRS

As described in section B.2 above, this RMP proposes to implement actions to improve water quality conditions in Copco and Iron Gate reservoirs. The actions considered in this RMP consist of proven techniques for lake and reservoir water quality management, such as described by Cooke and Kennedy (1989), Cooke et al. (2005), and Holdren et al. (2001). There are four basic categories of 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 (Cooke and Kennedy 1989, Cooke et al. 2005, Holdren et al. 2001). This section provides an overview of the four basic categories of techniques used for water quality improvements in reservoirs, and provides the justification for the specific techniques that PacifiCorp is evaluating to enhance water quality in Copco and Iron Gate reservoirs under this RMP.

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[45] As mentioned above, control of the large loads of nutrients and organic matter upstream of the Project is most appropriately addressed through controls on those upstream sources, for example through the implementation of TMDLs developed by ODEQ.

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 can often be effective techniques for addressing water quality improvements in reservoir and lakes, especially in cases (like the reservoirs on the Klamath River) where inflow water quality conditions and upstream loadings dictate in-reservoir (or in-lake) conditions. However, watershed and inflow water quality management measures are not included in this RMP because watershed and inflow water quality management is largely unaffected by and beyond the control of PacifiCorp's Project operations.

Improvements in watershed and upstream water quality are expected to occur in the future from the implementation of upstream actions by other entities in the watershed, particularly in Oregon, that address the Upper Klamath Lake and Klamath River TMDLs (ODEQ 2002, ODEQ 2010). The implementation and effects of such upstream actions should result in water quality improvements in the Project reservoirs because water quality conditions in the reservoirs are largely driven by the large nutrient and organic loads from upstream sources (notably Upper Klamath Lake).

A potential technique for watershed and inflow water quality management is construction of properly designed treatment wetlands that could offer a means of capturing and removing nutrients and particulate organic matter from inflows to the reservoirs. Since 2009, PacifiCorp has been conducting studies to determine the feasibility and effectiveness of constructing such treatment wetlands in the Project vicinity (Lyon et al. 2009, CH2M HILL 2012, PacifiCorp 2013). It is well established that wetlands can act as filters removing particulate material, as sinks that accumulate nutrients, or as transformers converting nutrients to different forms, such as gaseous compounds of nitrogen and carbon (Crites et al. 2003, Kadlec and Wallace 2008).

Lyon et al. (2009) conducted a preliminary feasibility assessment of the potential to use constructed wetlands to treat water quality at sites both upstream and within (or adjacent to) Copco and Iron Gate reservoirs. The upstream sites would be intended for treatment of water quality upstream of the reservoirs to remove nutrients and particulate organic matter (e.g., algae biomatter). The within (or adjacent) reservoir sites would be intended for treatment of accumulations of algae biomass within (or drawn from) the reservoirs, such as along-side reservoir coves.

As an action under this RMP, PacifiCorp plans to further assess the potential effectiveness and feasibility of constructing treatment wetlands upstream and/or along Copco and Iron Gate reservoirs based on study, analysis, and design tasks as described below in Section B.4 of this RMP. It is expected that this RMP action will focus on potential treatment wetlands that are located within (or adjacent to) the reservoirs, since such wetlands would more directly address in-reservoir water quality conditions. Upstream treatment 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 (PacifiCorp 2006, Butcher 2008, Asarian et al. 2009, NCRWQCB 2010). However, upstream wetlands will have less emphasis in this RMP because the large loads of nutrients and organic matter from upstream sources, notably Upper Klamath Lake, are unaffected by and beyond the control of PacifiCorp's Project operations.

B.3.2 Physical Water Quality Management Techniques

This category of reservoir management options involves physical techniques for water quality management, including:

- Hypolimnetic oxygenation
- Tailrace aeration or oxygenation
- Water column mixing and circulation
- Selective intake withdrawal control
- Reservoir drawdowns

In the following discussion, each of these physical techniques is defined and summarized relative to potential applicability to Copco and Iron Gate reservoirs.

B.3.2.1 Reservoir Hypolimnetic Oxygenation

Hypolimnetic oxygenation is a technique involving delivery and injection of oxygen to the deeper part (hypolimnion) of a reservoir (or lake) without disrupting vertical stratification of the water column. 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 (or lake), and retards the buildup of undecomposed organic matter and compounds (e.g., ammonium) in the hypolimnion.

Hypolimnetic oxygenation typically delivers and injects oxygen using one of two primary approaches: a bubble system or a bubble-free system. The bubble systems consist of pipes laid throughout the reservoir. Gaseous oxygen is delivered to porous pipes or similar diffuser-type fine bubble delivery system, which releases oxygen into the water. The bubble-free systems consist of a pressuring device into which the deep water is pumped to compress the oxygen into solution for an efficiency of almost 100 percent. Oxygen is often provided as liquid oxygen and stored adjacent to the reservoir, and also can be generated on site by a pressure swing compressor and molecular sieve.

The two main types of bubble oxygenators are: (1) the unconfined fine bubble diffuser; and (2) the unconfined and diffuse bubble curtain. The fine bubble diffuser sends oxygen to the bottom using discrete diffusers placed at a few locations along the bottom of the reservoir (or lake). 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 (MEI 2014).

In 2007, PacifiCorp retained Mobley Engineering, Inc. (MEI)[46] 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 the potential for substantial and sustained improvements in reservoir dissolved oxygen levels with the conceptual oxygen diffuser systems in operation.

[46] 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.

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 selection and implementation of specific technologies and measures to apply in both reservoirs.

The tasks associated with further consultation on, and the evaluation of these systems is described below in Section B.4 of this RMP.

B.3.2.2 Tailrace Aeration or Oxygenation

Tailrace aeration or oxygenation are techniques that add oxygen to the tailrace waters below dams and powerhouses. The addition of oxygen to tailrace waters is used to augment and elevate oxygen levels, if and when oxygen in water released from the dam or powerhouse is below desired levels. This technique increases the amount of oxygenated water available to organisms that use tailrace waters or other river habitats below the dam or powerhouse. Tailrace aeration or oxygenation techniques being considered in this RMP include: (1) turbine venting; (2) a forebay oxygen diffuser system; and (3) a side-stream oxygenation system.

Turbine venting uses a "reaeration valve" to allow the introduction 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, MEI (2005) assessed the potential implementation of a turbine venting system at the Iron Gate powerhouse. MEI (2005) estimated that turbine air admission would result in appreciable dissolved oxygen uptake, and that such uptake would enhance dissolved oxygen levels in the releases from the Iron Gate powerhouse. In 2007, FERC (2007) also 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) recommended a measure to include turbine venting and follow-up dissolved oxygen monitoring at Iron Gate.

Subsequently, PacifiCorp tested and evaluated passive venting of the turbine at the Iron Gate powerhouse in the fall of 2008. In 2009, PacifiCorp began implementing turbine venting at the Iron Gate powerhouse to improve dissolved oxygen concentrations downstream of Iron Gate dam. PacifiCorp installed a blower system at the Iron Gate powerhouse in January 2010 to enhance the effectiveness of turbine venting through increased air admission into the turbine draft tube. The combined system was tested in 2010 and demonstrated an ability to increase dissolved oxygen levels by up to 1.81 mg/L (PacifiCorp 2011). PacifiCorp has been implementing turbine venting on an ongoing basis since 2010 and developed a turbine venting Standard Operating Procedure (SOP) in early 2013 consistent with the terms of PacifiCorp's incidental take permit for coho salmon (PacifiCorp 2012)[47]. PacifiCorp plans to continue with further monitoring of turbine venting operations to verify air flow and dissolved oxygen increases, and to make adjustments (if needed), as described below in Section B.4 of this RMP.

[47] In February 2011, PacifiCorp filed the coho salmon HCP as part of an application for an incidental take permit (ITP) from the National Marine Fisheries Service (NMFS). The coho salmon HCP identifies a process to implement measures that will avoid, minimize, and mitigate the effects of Project operations on coho salmon and attain the biological goals and objectives described in the HCP's coho conservation strategy. Such measures include: (1) implementing habitat enhancement activities through a Coho Enhancement Fund; (2) implementing flow releases according to Reclamation's Biological Opinion for Coho Salmon, and turbine venting at Iron Gate dam to improve habitat conditions for coho salmon in the Klamath River; (3) funding research actions on Klamath River fish disease; (4) retrieval and passage of large wood debris trapped at PacifiCorp's facilities; and (5) monitoring to assess the benefits of these measures. On February 24, 2012, NMFS issued a final ITP that authorizes potential incidental take of coho salmon that could occur as a result of PacifiCorp's operation of the Project consistent with the terms of the HCP.

Another potential technique for augmenting tailrace oxygen is a forebay oxygen diffuser system. This system would consist of hypolimnetic bubble-type oxygenation system (such as described in Section B.3.2.1 above), but that is specifically sized and placed near the dam and powerhouse intake. In 2005, PacifiCorp retained MEI to evaluate the feasibility of placing an oxygen diffuser system in Iron Gate reservoir just upstream from the dam to assist in enhancing dissolved oxygen conditions in the releases to the Klamath River from the Iron Gate powerhouse (MEI 2005). To accomplish the oxygenation of hydropower releases, MEI (2005) recommended a system consisting of a grouping of three relatively short diffusers, approximately 1,500 feet long each and 60 to 90 feet deep, located just upstream of the powerhouse intake at Iron Gate dam. An oxygen supply facility located near Iron Gate dam would supply oxygen at set flow rates to the diffusers[48].

This 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 (MEI 2005). The oxygen delivery capacity of the system 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 near the powerhouse intake to improve water quality conditions. The system would maintain well-oxygenated conditions in the Iron Gate powerhouse releases to the Klamath River (MEI 2005).

The third technique for augmenting tailrace oxygen is a side-stream flow oxygenation system. This system would consist of a diversion facility and a contact chamber located alongside the upper end of the tailrace where liquid oxygen and water are combined to create supersaturated conditions (often in excess of 100 mg/L). An example of this type of system is the Supersaturated Dissolved Oxygen (SDOX™) system developed and manufactured by BlueInGreen, LLC of Fayetteville, Arkansas. SDOX™ is a patented/patents pending technology that maximizes the delivery of dissolved oxygen and minimizes the footprint of the oxygen delivery system. The SDOX™ operates in a manner whereby oxygen gas is pre-dissolved into a stream of water inside of a pressurized on-shore saturation tank to achieve supersaturated concentrations. The SDOX™ unit sprays water into the saturation chamber though nozzles to increase the surface area for oxygen transfer. The typical operating pressure within the SDOX™ unit is around 100 psi. At a water temperature of 20°C, the discharge oxygen concentration is approximately 290 mg/L. The oxygenated water is then released from the saturation tank and mixed with the larger body of water being treated.

A pilot scale trial of the SDOX™ system was conducted in PacifiCorp's J.C. Boyle reservoir in Oregon in September 2011 (CH2M HILL 2013). For this pilot test, a trailer-mounted SDOX™ 400 system, which has a full-rated capacity to deliver 1,540 pounds of dissolved oxygen per day (lbs/day), was deployed adjacent to the shoreline near the upper end of the reservoir. The SDOX™ system operated nearly continuously over a five-day test period, delivering an estimated total of 5,175 lbs of dissolved oxygen to the reservoir at an average rate of approximately 1,150 lbs/day. The pilot demonstration showed formation of a dissolved oxygen plume mainly along the southern portion of the reservoir downstream of the injection point, and a rise in dissolved oxygen levels within the plume area of at least 0.5-1.5 mg/L (CH2M HILL 2013). While this test location did not have dissolved oxygen and hydraulic conditions that are exactly comparable to the Iron Gate tailrace, this testing, as well as tailrace applications elsewhere (e.g., Osborn et al. 2009), suggest that the SDOX™ system can increase dissolved oxygen levels in treated waters.

RMP measures proposed by PacifiCorp with regard to these three tailrace aeration or oxygenation techniques are described further below in Section B.4 of this RMP. As noted above, PacifiCorp plans to

[48] 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.

continue with further monitoring of turbine venting operations and resultant tailrace dissolved oxygen increases, and to make adjustments (if needed), as described in Section B.4 of this RMP. To date, monitoring indicates that turbine venting is sufficient to help maintain tailrace dissolved oxygen at levels that protect beneficial uses (as described in Section 5.2.1 in the WQC application). However, if additional tailrace dissolved oxygen augmentation is needed, PacifiCorp will proceed to conduct additional evaluations of potential tailrace oxygenation (using the hypolimnetic diffuser or side-stream oxygenation) as described below in Section B.4 of this RMP.

B.3.2.3 Water Column Mixing and Circulation

Water column mixing and circulation 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. There are two broad categories of mixing and circulation that are used in reservoir management and that are distinguishable by the extent and location of reservoir waters to be mixed. The two categories are: (1) mixing and circulation involving only surface layers or shallow locations of the reservoir (epilimnion); and (2) mixing and circulation of the entire vertical water column at deeper reservoir areas to promote destratification.

Surface Mixing and Circulation

Surface (epilimnetic) mixing and circulation typically use mechanical devices to mix water in the surface layer of a reservoir to directly control algae growth by mixing the algae out of the euphotic zone into darker water. The agitation caused by this circulation reduces algae production by disrupting the conditions they prefer for bloom formation, and indirectly controls elevated pH.

Surface (epilimnetic) mixing and circulation is being evaluated for Copco and Iron Gate reservoirs under this RMP as a means of mixing water and minimizing quiescent conditions in the warmer surface layers of the reservoirs during summer, including in coves or embayments. 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 contribute to bloom formation.

Several types of mechanical mixing devices (aerators and circulators) are commercially available for potential application for surface (epilimnetic) mixing and circulation. One of the more commonly-used device is an axial flow pump, which uses a “top-down” approach to set up a circulation pattern. An axial flow pump includes a floatation platform and frame that supports an electric motor, gearbox, drive shaft, and large propeller (6- to 15-foot diameter). The propeller is suspended just a few feet below the water surface. Its rotation “pushes” water from the reservoir surface downward, setting up a vertical circulation pattern.

In 2007 and 2008, PacifiCorp conducted pilot demonstration projects of solar-powered water circulators in Copco reservoir. Monitoring data obtained during these tests indicated that the solar-powered circulators did not act to discernibly improve water quality, and in particular did not act to reduce blue-green algae blooms (Carlson and Foster 2009). CH2M HILL (2013) indicated that the solar-powered water circulators produce a lower-energy laminar flow circulation to create mixing, which differs from the turbulent mixing approach produced by higher-energy axial flow pumps. This lower-energy approach has the advantage of substantially lower energy costs for operations, but has the disadvantage of less energetic mixing that may not be adequate in certain applications.

In 2013, PacifiCorp completed an initial evaluation of higher-energy mechanical mixing systems for potential use in PacifiCorp's J.C. Boyle reservoir in Oregon (CH2M HILL 2013). PacifiCorp proposes to conduct a similar assessment and additional testing of such systems in Copco and Iron Gate reservoirs as described below in Section B.4 of this RMP. Such evaluation and additional testing is needed to gain better reliability and effectiveness information prior to further design and potential scale-up to more extensive implementation in Copco and Iron Gate reservoirs. In addition, it is possible that further evaluation and testing of a potential mechanical mixing system could indicate that this system would be redundant or unnecessary if other RMP measures (e.g., oxygenation, drawdown) achieve the same or better dissolved oxygen improvement or blue-green algae bloom control. As such, a decision to pursue (or not) the further design and implementation of a mechanical mixing system will be determined in coordination with the evaluations of the other oxygenation and mixing systems.

<u>Water Column Mixing to Promote Destratification</u>

Mixing and circulation to promote destratification is typically 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 conduct further evaluation of potential destratification of Copco and Iron Gate reservoirs under this RMP. Destratification can be difficult and uncertain to achieve in reservoirs that stratify strongly, such as in Iron Gate reservoir and to a lesser extent Copco reservoir. In addition, destratification would likely reduce the availability and amount of cool water storage in Iron Gate reservoir that is used by the Iron Gate Hatchery. While destratification could be a reservoir management tool that helps to improve water quality, PacifiCorp will defer further evaluation pending the outcome of the planned evaluations of the other oxygenation and mixing systems (as described in this RMP).

B.3.2.4 Selective Intake Withdrawal Control

Selective intake withdrawal control involves strategies intended to enhance water quality in waters released at the dam or powerhouse by selecting for or controlling the levels at which reservoir water are drawn into the powerhouse intake near the dam. For purposes of this RMP, selective intake withdrawal control is specifically of interest for its potential to: (1) reduce the amount of algae entrained into the Iron Gate intake and discharged downstream from the powerhouse; and (2) withdraw cold water from the deeper water of Iron Gate reservoir to provide downstream cooling at specific times of year.

Regarding the first purpose (algae control), PacifiCorp implemented a multi-year study (starting in 2009) to assess the efficacy of an intake cover intended to reduce blue-green algae entrainment into the existing Iron Gate reservoir intake (Watercourse 2013c, Watercourse 2014b). The objective of the study is to evaluate the potential use and effectiveness of an intake cover, or other exclusion methods (e.g., geotextile curtains), for controlling the depth at which intake waters are withdrawn from the reservoir at or near the surface. This selective withdrawal control could provide a method for potentially reducing the amount of algae entrained into the Iron Gate intake and discharged from the powerhouse. Additional reservoir intake testing is occurring during summer 2014 and results are pending.

Regarding the second purpose (temperature control), PacifiCorp's FLA (PacifiCorp 2004b) describes a potential measure to implement a low-level release of cooler hypolimnetic water from Iron Gate reservoir during late summer and fall 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. In addition, the 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 have effects on the hatchery that would need to be addressed.

PacifiCorp has 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 cool 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 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.

PacifiCorp's modeling results indicate that if releases from Iron Gate dam are managed to sustain decreased temperatures, hourly temperatures in releases from Iron Gate dam 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 release water temperature, a maximum reduction of up to 10°C is possible in the releases from Iron Gate dam, but would last only for a few days until the cold water pool is depleted. The potential cooling benefits from the releases would be most prominent in the tailwaters below the dam, but then progressively diminish with distance below the dam as the river responds to changes in meteorological and tributary inflow conditions.

PacifiCorp proposes to conduct additional evaluation and testing of intake withdrawal control, specifically in Iron Gate reservoir as described below in Section D.4 of this RMP. Such additional evaluation and testing is needed to gain better reliability and effectiveness information prior to further design and potential implementation.

B.3.2.5 Reservoir Drawdown and Fluctuation

In concept, lowering and fluctuating reservoir water levels can facilitate water quality improvement in two ways. One way is through increasing the rate of reservoir flushing (by reducing reservoir volume) and thereby improving reservoir water quality by: (1) a decrease in algae abundance by washout; and (2) potential improvement in some attributes (e.g., dissolved oxygen, pH) through more rapid replenishment of reservoir water. A second way is through exposing the reservoir's bottom sediments to oxidize them and decrease their oxygen demand and long-term nutrient release rate when subsequently re-inundated.

Under existing conditions, drawdown in Copco and Iron Gate reservoirs is limited to about 6.5 feet and 4.0 feet (i.e., the difference in the normal maximum and normal minimum operating levels), respectively. A drawdown of 6.5 feet and 4.0 feet, respectively, does not significantly decrease the reservoir's hydraulic retention time (HRT), and thus does not produce appreciable changes in the reservoir's limnological and water quality character. In addition, under a drawdown of 6.5 feet and 4.0 feet, respectively, the exposed area of sediments along the periphery of the reservoirs is a minor amount of the total sediment area. Also, sediment oxygen demand is a secondary factor affecting dissolved oxygen in the reservoirs compared to algae respiration and advected (inflow-related) oxygen demanding materials.

In the Final Environmental Impact Statement (FEIS) issued in November 2007 for the proposed relicensing of the Project, FERC staff recommended a measure involving deeper experimental drawdown of Copco and Iron Gate reservoirs. This measure would evaluate the effects of decreased reservoir volume on passage survival through the reservoir of juvenile salmon (assuming future salmon reintroduction), and on downstream water quality conditions, including the presence of microcystin (i.e., the toxin that can be produced by *Microcystis*). In addition to improving juvenile salmon migration, FERC (2007) also assumed that reservoir drawdown could reduce algal blooms and resultant potential effects on downstream water quality. FERC (2007) recommended that the experimental drawdown of Copco and Iron Gate reservoirs consist of lowering the water elevations in each reservoir by about 22 feet below the normal pool level in both reservoirs from May through November. FERC (2007) estimated 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.

The 40 percent reduction in the volume of Copco and Iron Gate reservoirs (associated with the deeper 22-foot drawdown) would act to reduce algal blooms and resultant potential effects on downstream water quality through enhanced reservoir flushing. Flushing is a documented reservoir (and lake) management technique that involves adding large amounts of water to a reservoir (or lake), whether low in nutrients or not, to flush algae out of the reservoir faster than it can reproduce (Cooke et al. 2005). For example, this technique has been applied over several years to successfully reduce algal blooms and improve water quality conditions in hypereutrophic Moses Lake, Washington (Cooke et al. 2005, Welch and Weiher 1987). A flushing rate of about 10 to 20 percent of the reservoir's volume per day is considered necessary for this purpose (Cooke et al. 2005, Welch and Weiher 1989).

As mentioned above, the normal minimum operating levels of Copco and Iron Gate reservoirs equate to drawdowns of about 6.5 feet and 4.0 feet, respectively, from normal maximum operating levels. At these drawdown levels, a flushing rate of 10 to 20 percent per day equates to an inflow rate of about 1,680 to 3,360 cfs in Copco reservoir and an inflow rate of about 2,340 to 4,680 cfs in Iron Gate reservoir. 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.

By comparison, at a potential deeper 22-foot drawdown, a flushing rate of 10 to 20 percent per day equates to an inflow rate of about 1,050 to 2,100 cfs in Copco reservoir and about 1,800 to 3,600 cfs in Iron Gate reservoir. While the flow quantities over much of these ranges also are typically not available during the primary June-October algae growth period, there is a reasonable likelihood that the flow quantity at the lower end of the range will be available. If available, such changes in the reservoirs' HRT could result in positive effects on water quality. As such, PacifiCorp plans to further assess the potential for, and effectiveness of, seasonal deeper drawdown (fluctuation) of Copco and Iron Gate reservoirs as described below in Section B.4 of this RMP.

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).

B.3.3.1 Algaecides

Algaecides have traditionally been used in lake and reservoirs to prevent algae blooms (Cooke and Kennedy 1989, Cooke et al. 2005, Holdren et al. 2001). Algaecide treatments have been an important in the treatment of drinking water supply reservoirs and have allowed safe swimming in many recreational lakes (Holdren et al. 2001).

Since 2009, PacifiCorp has conducted limited test applications of a hydrogen peroxide-based algaecide (GreenClean PRO™) in two coves, one in Copco and one in Iron Gate reservoir (Deas et al. 2012, Deas et al. 2014). Hydrogen peroxide (H_2O_2), such as in the form sodium carbonate peroxyhydrate (SCP), is an environmentally-safe algaecide 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 SCP 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 the State Board's Resolution No. 2006-0039). By-products of SCP include oxygen and water.

Recent research (Barrington, et al. 2013, Matthijis, et al. 2011) indicates that hydrogen peroxide application to cyanobacteria blooms can rapidly reduce both cyanobacteria and microcystin concentrations in water bodies while promoting more favorable phytoplankton assemblages. Oxidation due to hydrogen peroxide treatment can directly reduce dissolved microcystin, and reductions are markedly increased where ultraviolet light (UV) is present (Qian et al. 2010, Matthijs et al. 2011). These findings are consistent with the idea that hydrogen peroxide, a strong oxidant, is able to oxidize microcystin during or immediately following lysis of targeted algal cells. Barrington et al. (2013) reported that while cell lysing occurred with hydrogen peroxide application, total microcystin was reduced for up to three weeks following treatment. Further, dissolved microcystin continued to decrease to non-detectable levels a few days after treatment. Because hydrogen peroxide oxidizes out the system quickly (e.g., hours), these declines in microcystin concentrations may be due to UV radiation, bacterial activity or other environmental factors.

PacifiCorp plans to proceed with further effectiveness testing of SCP (GreenClean PRO™) applications in Copco and Iron Gate reservoirs based on additional test applications to limited and confined areas of the reservoirs. PacifiCorp will continue to obtain the necessary approval from the State Water Board and other appropriate regulatory authorities for such testing. The tasks associated with this testing are described below in Section B.4 of this RMP.

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 ("alum") is the most widely used method for phosphorus inactivation or settling (Cooke et al. 2005). Aluminum sulfate has been used in dozens of lakes in the United States and Europe to remove excess phosphorous and thus reduce algae.

PacifiCorp does not propose to consider phosphorus inactivation or settling agents further under this RMP because it likely would be ineffective and uneconomical. As described above, Copco and Iron Gate reservoirs are subject to very high inflowing (external) phosphorus loads from upstream sources, particularly Upper Klamath Lake. As such, Copco and Iron Gate reservoirs are not good candidates for use of phosphorus inactivation or settling agents because the large upstream phosphorus inputs likely would overwhelm the effects from applications of such agents in the reservoirs.

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

In concept, biological techniques (often referred to as "biomanipulation") prevent algal biomass from accumulating to high levels 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). While biomanipulation techniques are appealing in their use of natural ecological principles to control algae, they are largely experimental and 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 (since such reductions in fish would have the effect of also increasing zooplankton and thus accomplish both of the above ways of reducing algal biomass accumulation). However, appreciable removal of these fish would be very difficult and would adversely affect the popular recreational fishery that exists in the reservoirs. PacifiCorp does not propose to consider biomanipulation further under this RMP.

B.4 PROPOSED ACTIVITIES FOR EVALUATION, PLANNING, AND IMPLEMENTATION OF MEASURES FOR WATER QUALITY IMPROVEMENTS IN COPCO AND IRON GATE RESERVOIRS

This section describes the specific planned activities and actions by PacifiCorp for further evaluation, design, and implementation of techniques for water quality improvements in Copco and Iron reservoirs. As described above in Section B.3 of this RMP, these actions include: (1) constructed wetlands conceptual design and implementation planning; (2) further evaluation of tailrace aeration and oxygenation systems; (3) design and implementation planning of reservoir oxygenation systems; (4) evaluation of epilimnion (surface water) mixing and circulation; (5) further evaluation of selective withdrawal and intake control; (6) modeling and testing of deeper seasonal drawdown and fluctuation of the reservoirs; and (7) additional testing and controlled applications of SCP algaecide to treat localized areas (e.g., coves, embayments) in the reservoirs.

B.4.1 Constructed Wetland Conceptual Design and Implementation Planning

As an action under this RMP, PacifiCorp plans to further assess the potential effectiveness and feasibility of constructing treatment wetlands alongside (or perhaps upstream of) Copco and Iron Gate reservoirs as described in Section B.3 above. The tasks and activities to be performed under this measure will include:

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on plans for potential constructed wetlands and the water quality enhancements to be addressed.

- PacifiCorp will conduct conceptual design and implementation planning for potential use of constructed wetlands as a management measure to help address water quality conditions within Copco and Iron Gate reservoirs. This conceptual design and implementation planning will build on the previous initial feasibility study conducted by Lyon et al. (2009) on potential use of constructed wetlands to enhance the water quality in the reservoirs.

- Design and implementation of constructed wetlands will require an iterative process. PacifiCorp will determine treatment objectives and candidate locations for potential constructed wetlands. Consultation (as described in the bullet above) and existing site-specific information (including the previous feasibility study by Lyon et al. [2009]) will be used to determine the treatment objectives and candidate locations for potential constructed wetlands. As described in Section B.3 above, emphasis likely will be placed on potential treatment wetlands within (or adjacent to) the reservoirs, since such wetlands would more directly address in-reservoir water quality conditions. Upstream treatment wetlands could help to address the large loads of nutrients and organic matter from upstream sources, but such loads are unaffected by and beyond the control of PacifiCorp's Project operations.

- Design guidelines for the constructed wetlands will be established (based on treatment objectives and locations) for desired removal efficiency of nutrients and organic matter loads that would flow through the wetlands. The treatment objectives will also include an assumed water budget developed from estimates of the quantities of water inflows to the constructed wetlands systems from the adjacent reservoir or river upstream, and the outflows, including the net losses through evapotranspiration and groundwater.

- PacifiCorp will determine site conditions at candidate wetland locations. Site-specific conditions need to be characterized at candidate locations of constructed wetlands to facilitate conceptual design and implementation planning. Considerations will include available land area and ownership, topography, soil types, hydrologic conditions, role of groundwater, and presence of existing wetlands or sensitive flora and fauna on potential sites.

- PacifiCorp will prepare conceptual layouts of potential constructed wetlands. Results from the activities described above will be used to prepare a conceptual layout for the wetlands that are proposed for potential construction and implementation.

- The information developed from the activities described above will be compiled in a conceptual design and implementation plan document. This plan document will discuss the results of the activities described above, including a conceptual layout of the proposed constructed wetlands system. The plan document will also discuss the approach and steps for the next phase of project implementation, including wetland construction, operation, and maintenance.

PacifiCorp will complete the work itemized above according to a specific schedule to-be-determined following consultation with the State Water Board and other applicable regulatory authorities on plans for potential constructed treatment wetlands.

B.4.2 Further Evaluation of Tailrace Aeration or Oxygenation for Dissolved Oxygen Enhancement below Iron Gate Dam

PacifiCorp plans to proceed with further monitoring and evaluation of turbine venting at the Iron Gate powerhouse and potential tailrace oxygenation (if needed) as described in Section B.3 above. The tasks and activities to be performed under this measure will include:

- PacifiCorp will conduct on-going monitoring of turbine venting at Iron Gate powerhouse. Monitoring of turbine venting operations at the Iron Gate powerhouse will continue on an on-going basis, including monitoring of dissolved oxygen (in mg/L and percent saturation) in the Klamath River just downstream of the powerhouse. Monitoring will verify turbine venting air flow and dissolved oxygen increases that are achieved with turbine venting.

- The monitoring information (as described above) will be used to evaluate the extent of turbine venting air flow and dissolved oxygen increases that are achieved with turbine venting. If the monitoring information indicates that adjustments are needed, PacifiCorp will make necessary adjustments to the existing turbine venting system, or evaluate other methods as appropriate to increase turbine air entrainment (and presumably dissolved oxygen), such as hub baffles on vacuum breaker vents and draft tube air entrainment.

- 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 monitoring and evaluation, including any adjustments recommended or made.

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on the extent of dissolved oxygen enhancement in the tailwaters below Iron Gate dam and the need (if any) for additional augmentation of dissolved oxygen.
- If additional augmentation of dissolved oxygen is warranted, PacifiCorp will further evaluate potential oxygenation systems. The further evaluation will build on the previous studies of MEI (2005), MEI (2007), and CH2M HILL (2013) to identify the most appropriate and feasible system (such as the hypolimnetic or side-stream oxygenation systems described in Section B.3.2.2 above).
- PacifiCorp will then prepare the design and installation plans of the oxygenation system to be implemented. The design-related tasks could include some additional modeling of possible alternative system configurations and field testing of prototypes.
- The information developed during the proposed work will be compiled in a technical report. The report will describe and discuss the design and implementation plans of the potential reservoir and tailrace oxygenation systems. The conclusions and recommendations of the report will serve as a guide for the subsequent implementation and monitoring phase of systems development.

PacifiCorp will complete the work itemized above according to a specific schedule to be determined following consultation with the State Water Board and other applicable regulatory authorities on turbine venting performance and possible subsequent evaluation of tailrace oxygenation (if needed).

B.4.3 Design and Implementation Planning of Reservoir Oxygenation Systems

PacifiCorp plans to proceed with design and implementation planning of potential reservoir oxygenation systems for injection of oxygen (and associated enhanced dissolved oxygen) as described in Section B.3 above. This design and implementation planning will emphasize potential use in the hypolimnion of Iron Gate reservoir, but application at Copco reservoir is also possible depending on further consultation with the State Water Board and other applicable regulatory agencies (as described further in the first bullet below).

The tasks and activities associated with design, testing, and implementation planning of these systems will include:

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on plans for reservoir oxygenation systems and the water quality enhancements to be addressed.
- PacifiCorp will prepare the design and implementation details of potential reservoir oxygenation systems. The design and implementation plans will build on the previous studies of MEI (2005), MEI (2007), and CH2M HILL (2013) to address system sizing, equipment, layout, and installation locations. The design-related tasks could include some additional modeling of possible alternative system configurations and field testing of prototypes.
- The information developed during the proposed work will be compiled in a technical report. The report will describe and discuss the design and implementation plans of the potential reservoir oxygenation systems. The conclusions and recommendations of the report will serve as a guide for the subsequent implementation and monitoring phase of systems development.

PacifiCorp will complete the work itemized above according to a specific schedule to be determined following consultation with the State Water Board and other applicable regulatory authorities on plans for potential reservoir oxygenation systems.

B.4.4 Evaluation of Epilimnion (Surface Water) Mixing and Circulation

PacifiCorp plans further evaluation and pilot-scale testing of mechanical mixing devices (aerators and circulators) for potential application for surface (epilimnetic) mixing and circulation in Copco and Iron Gate reservoirs as described in Section B.3 above. Such further evaluation and testing is needed to gain better reliability and effectiveness information prior to potential scale-up to more extensive implementation in the reservoirs. The tasks and activities to be performed under this measure will include:

- PacifiCorp will determine the need for potential reservoir mixing and circulation systems. As described in Section B.3.2.3 above, a potential reservoir mixing and circulation system could be redundant or unnecessary if other RMP measures (e.g., oxygenation, drawdown) achieve the same or better dissolved oxygen improvement or blue-green algae bloom control. As such, a decision to pursue (or not) the further design and implementation of a mechanical mixing system will be determined in coordination with the evaluations of potential oxygenation systems or other algal-control measures.
- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on plans for potential reservoir mixing and circulation systems.
- PacifiCorp will determine the mechanical mixing devices to be evaluated and tested under this measure. PacifiCorp will evaluate the mechanical mixing devices based on water quality modeling (using existing reservoir models) of possible alternative system configurations, preliminary design calculations (such as used in CH2M HILL [2013]), and possible field testing of prototypes. The field testing of prototypes would include monitoring of water quality before, during, and after deployment of the prototypes to monitor their effectiveness.
- The information developed during the proposed work will be compiled in a technical report and implementation plan document. This plan document will discuss the results of the activities described above, including the recommended approach to potential future deployment of mixers or circulators in Copco and Iron Gate reservoirs. The plan document will also discuss the approach and steps for the next phase of project implementation.

PacifiCorp will complete the work itemized above according to a specific schedule to-be-determined following consultation with the State Water Board and other applicable regulatory authorities on plans for potential reservoir mixing and circulation systems.

B.4.5 Evaluation of Selective Withdrawal and Intake Control

PacifiCorp plans further evaluation of selective withdrawal and intake control at Iron Gate dam as described in Section B.3 above. Such further evaluation is needed to gain better reliability and effectiveness information prior to potential implementation of selective withdrawal and intake control at Iron Gate dam. The tasks and activities to be performed under this measure will include:

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on plans for potential selective withdrawal and intake control at Iron Gate dam.
- PacifiCorp will determine whether selective withdrawal of cold water from the deeper water of Iron Gate reservoir should be pursued. As described in Section B.3 above, the cold water pool that occurs in Iron Gate in summer and early fall is limited. Potential cooling effects in releases from the reservoir would be limited in magnitude and duration, and would progressively diminish with distance below the dam as the river responds to changes in meteorological and tributary inflow conditions (PacifiCorp 2005b, PacifiCorp 2005c). In consultation with the State Water Board and

other applicable regulatory agencies, PacifiCorp will determine whether reservoir selective withdrawal would enhance protection of beneficial uses downstream. Furthermore, in consultation with the State Water Board and other applicable regulatory agencies, PacifiCorp will determine whether or not use of the cold water pool in Iron Gate reservoir should be pursued in light of the potential detrimental effect on Iron Gate Hatchery that would occur (since the hatchery relies on use of the cold water pool in Iron Gate reservoir).

- If pursued, the approach to the implementation of the selective withdrawal system will be evaluated. This evaluation will determine possible components and layouts for the selective withdrawal system, and assess relative feasibility and costs to construct and operate. The evaluation will also determine the approach and steps for the next phase of project implementation.
- PacifiCorp will assess the feasibility and effectiveness of alternative intake cover configurations to reduce algae entrained into the Iron Gate intake and discharged downstream from the powerhouse. PacifiCorp will use modeling and field testing to determine the feasibility and effectiveness of various intake cover types and configurations to reduce the amount of blue-green algae (notably Microcystis) entrained into the Iron Gate intake and discharged downstream. In addition to intake cover configurations, other exclusion methods, such as installations of surrounding geotextile curtains, will be considered. The field testing of intake cover configurations would include monitoring of water quality before, during, and after deployment to monitor the effectiveness of configurations.
- The information developed during the proposed work will be compiled in a technical report and implementation plan document. This plan document will discuss the results of the activities described above, including the recommended approaches to potential selective withdrawal and intake control at Iron Gate dam. The plan document will also discuss the approach and steps for the next phase of project implementation.

PacifiCorp will complete the work itemized above according to a specific schedule to-be-determined following consultation with the State Water Board and other applicable regulatory authorities on plans for potential selective withdrawal and intake control at Iron Gate dam.

B.4.6 <u>Analysis of Potential Seasonal Drawdowns and Fluctuations of Copco and Iron Gate Reservoirs</u>

PacifiCorp plans further evaluation of potential deeper seasonal drawdowns and fluctuations of Iron Gate and Copco reservoirs as described in Section B.3 above. Such further evaluation is needed to gain better reliability and effectiveness information prior to potential implementation of deeper seasonal drawdowns and fluctuations of the reservoirs. The tasks and activities to be performed under this measure will include:

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities on plans for potential deeper seasonal drawdowns and fluctuations of Iron Gate and Copco reservoirs.
- PacifiCorp will determine the specific approach to seasonal drawdown (fluctuation) of the reservoirs, including the timing (i.e., season or month of occurrence), duration (i.e., length of time that the drawdown would occur), and magnitude (e.g., the level of drawdown depth, inflow quantity, and HRT to be achieved). This approach will be based on: (1) consultation with the State Water Board and other applicable agencies (as described in the bullet above); (2) information on the approaches to drawdowns of other similar reservoirs elsewhere (as reported in the research literature); and (3) modeling of drawdown scenarios (using PacifiCorp's existing models of the reservoirs).
- Modeling will be performed using PacifiCorp's water quality modeling framework that was developed for the Project's FERC relicensing studies (PacifiCorp 2004b, 2006). Modeled scenarios

will include (but not necessarily be limited to) 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 (e.g., 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, and algal production.

- Conduct field tests as needed to evaluate potential implementation and effectiveness of seasonal drawdown.

- The information developed during the proposed work will be compiled in a technical report. The report will describe and discuss the approach to, and testing of, seasonal drawdown (fluctuation) events. The conclusions and recommendations of the report will serve as a guide for the implementation and monitoring phase of seasonal drawdown (fluctuation) in the future.

PacifiCorp will complete the work itemized above according to a specific schedule to-be-determined following consultation with the State Water Board and other applicable regulatory authorities on potential seasonal drawdown (fluctuation) of the reservoirs.

B.4.7 Additional Testing and Controlled Applications of Sodium Carbonate Peroxyhydrate (SCP) Algaecide in Localized Areas in Copco and Iron Gate Reservoirs

PacifiCorp plans to conduct additional testing and controlled applications of SCP in localized areas (e.g., coves, embayments) in Copco and Iron Gate reservoirs for preventing or reducing blooms of blue-green algae such as *Microcytis* (as described in Section B.3 above). Effective control of blue-green algae in certain localized areas, including those with consistent public use, would reduce the public health risk associated with exposure to potential microcystin toxins produced by blue-green algae such as *Microcytis*. The tasks and activities associated with these test applications will include:

- PacifiCorp will consult with the State Water Board and other applicable regulatory authorities to acquire approvals as needed for testing and controlled applications of SCP in localized areas (e.g., coves, embayments) in Copco and Iron Gate reservoirs.
- PacifiCorp will conduct testing and controlled applications of SCP algaecide (GreenClean PRO™) during the summer in limited or confined areas in the reservoirs. The additional testing and controlled applications will build on bench-scale tests and localized field trials conducted by PacifiCorp (Deas et al. 2012, Deas et al. 2014). For the additional testing and controlled applications, PacifiCorp will continue to consult with technical experts and manufacturers on the most appropriate application methods and dosages to use. PacifiCorp also will continue to retain the services of experienced and certified professional specialists to perform the applications.
- PacifiCorp will monitor the effectiveness of the controlled, localized applications. Water quality will be monitored before, and after test applications, and will include in-situ sampling required by the state permit, as well as water clarity (i.e., Secchi depth), temperature, dissolved oxygen, and pH; epilimnetic chlorophyll a and phytoplankton composition; and microcystin concentration.
- The information developed during the testing and controlled applications will be compiled in a technical report. The conclusions and recommendations of the report will serve as a guide for potential future additional applications of SCP algaecide at public access coves in Copco and Iron Gate reservoirs.

PacifiCorp will complete the work itemized above according to a specific schedule to-be-determined following consultation with the State Water Board and other applicable regulatory authorities on potential seasonal drawdown (fluctuation) of the reservoirs.

B.4.8 Water Quality Monitoring

PacifiCorp plans to conduct water quality monitoring in the vicinity of the Project during the planning and implementation activities under this RMP. This monitoring will provide key information for PacifiCorp's design and testing of RMP actions in support of PacifiCorp's water quality certification for the Project from the State Water Board.

B.4.8.1 Basic Water Quality Monitoring

Basic water quality monitoring will be performed in conjunction with the planning and implementation activities under this RMP as a continuation of work that has been carried out over several previous years to describe water quality conditions in the Project area (PacifiCorp 2004b, PacifiCorp 2008a, PacifiCorp 2008b, Raymond 2009a, Raymond 2009b, Raymond 2010a, Raymond 2010b, Watercourse 2011a, Watercourse 2011b, Watercourse 2012, Watercourse 2013b). This monitoring will occur at the following locations in California:

- 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

Samples and measurements will be taken at the river and reservoir sites monthly November through May 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 species. 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).

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 nitrogen (TN), 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, and algae speciation, density, and biovolume. 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.4.8.2 Continuous Monitoring

PacifiCorp will continue to maintain 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). This automated water quality station utilizes an automated multiparameter data sonde installed in the vicinity of the hatchery bridge below Iron Gate dam.

B.4.8.3 Public Health Monitoring

The presence and quantities of *Microcystis* and associated microcystin toxins will continue to be monitored in Copco and Iron Gate reservoirs and the Klamath River below Iron Gate dam. Since 2009, PacifiCorp has been conducting public health monitoring for blue-green algae and microcystin toxin in water samples at four shoreline sites in coves in Copco reservoir (Copco and Mallard coves) and Iron Gate reservoir (Camp Creek and Mirror coves) and at the hatchery bridge below Iron Gate dam. Public health sampling in Copco and Iron Gate reservoirs will begin in May, and then continue until the reservoirs are posted with health advisories[49], which usually happens by the end of July. Public sampling in the reservoirs resumes again in October for the purpose of de-posting the health advisories. Weekly public sampling at the hatchery bridge begins in July and continues until all evidence of algal bloom conditions have disappeared.

Public health samples are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Samples for potentially toxic phytoplankton are preserved in Lugol's solution, and blue-green algae species are reported as individual cells per milliliter. Samples for determination of microcystin toxin are analyzed using the competitive Enzyme-Linked ImmunoSorbent Assay (ELISA) method based on the EnviroLogix QuantiPlate Kit for microcystins. The quantitation limit is 0.18 μg/L or parts per billion (ppb). This test method does not distinguish between the specific microcystin congeners, but detects their presence to differing degrees. That is, ELISA test results yield one value as the sum of measurable microcystin variants.

Public health monitoring of blue-green algae and toxins requires prompt and effective communication of data to the local and state agencies to support management decisions regarding the need to post waterbodies with informational signage or issue health advisories. Thus, results from blue-green algae cell count and toxin analyses are forwarded promptly to the appropriate local and state health agencies (e.g., California Regional Board). PacifiCorp also produces a memorandum every two weeks with the most recent analytical results and distributes that memo to regulatory agencies and interested parties including the Klamath Basin Monitoring Program (KBMP). These public health memos are posted on the KBMP website (www.kbmp.net) and PacifiCorp's website.

[49] The California State Water Resources Control Board (SWRCB 2010) and Oregon Department of Health Services (ODHS 2005) provide guidelines for posting advisories in recreation waters. These guidelines were developed using information provided in WHO (2003). Both SWRCB (2010) and ODHS (2005) recommend posting advisories in recreation waters under three circumstances: (1) if "scum is present associated with toxigenic species"; (2) if scum is not present, but the density of *Microcystis* or *Planktothrix* is 40,000 cells/ml or greater; and (3) if scum is not present, but the density of all potentially toxigenic blue-green algae is 100,000 cells/ml or greater. Based on WHO (2003) information, SWRCB (2010) and ODHS (2005) indicate that cell counts of 40,000 and 100,000 cells/ml equate to microcystin toxin concentrations of 8 μg/L and 20 μg/L, respectively.

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 RMP 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 RMP 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 to support the RMP 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.

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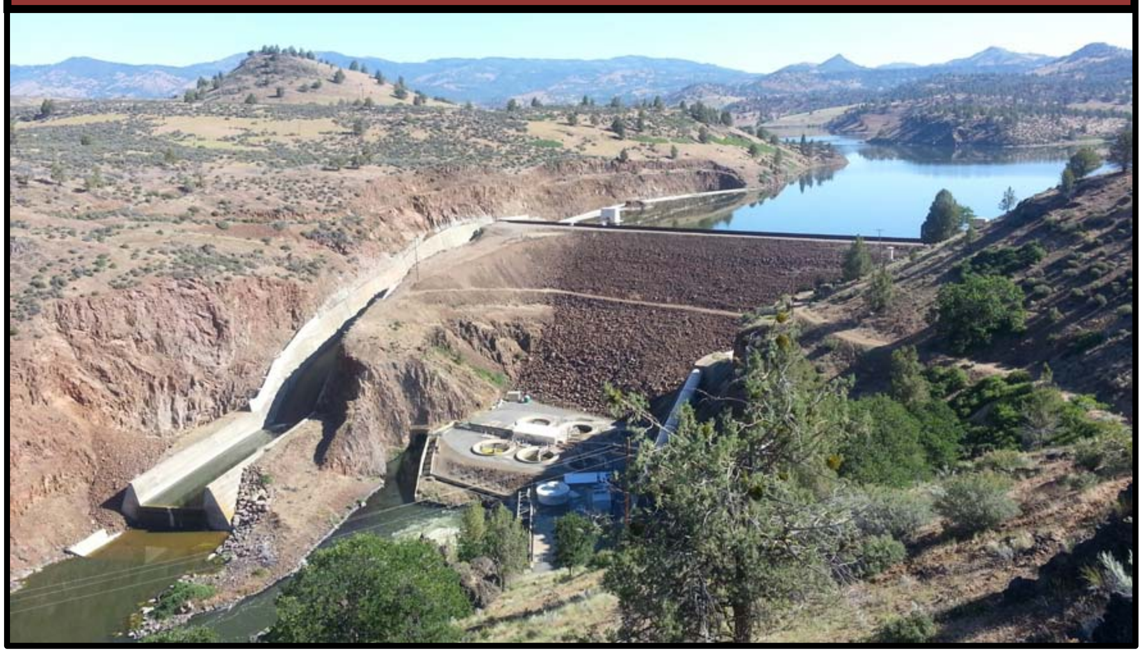
Klamath Hydroelectric Settlement Agreement

Implementation Report

Klamath Hydroelectric Project



FERC Project No. 2082

PACIFICORP ENERGY
A DIVISION OF PACIFICORP

June 2014

Executive Summary

This report highlights the accomplishments and activity related to implementation of the Klamath Hydroelectric Settlement Agreement since the agreement was signed on February 18, 2010. This is the fourth annual implementation report and focuses on events that occurred between June 2013, when the third report was issued, and June 2014.

Federal Legislation

On June 20, 2013, a hearing on Klamath River Basin water resources issues was held in the U.S. Senate Committee on Energy and Natural Resources. Shortly after the hearing, Senators Wyden and Merkley from Oregon, Governor Kitzhaber of Oregon, and Representative Walden convened the Klamath Basin Task Force to address remaining issues relevant to implementation of the Klamath Settlements. With completion of the Klamath Task Force efforts in early 2014, Senators Wyden, Merkley, Feinstein, and Boxer introduced new legislation (S. 2379) into the U.S. Senate in May, 2014 that would implement the KHSA, the Klamath Basin Restoration Agreement, and the Upper Basin Comprehensive Agreement. The Senate Committee on Energy and Natural Resources held a hearing on the proposed legislation on June 3, 2014 to gather testimony from stakeholders regarding the Klamath settlements.

Secretarial Determination and Environmental Review

On April 4, 2013, the Department of the Interior released a Final Environmental Impact Statement (Final EIS) and related scientific/technical reports. Under the terms of the KHSA, the studies and environmental review will inform the Secretarial Determination on whether to proceed with facilities removal under the agreement.

Dam Removal Funding

The California and Oregon public utility commissions have authorized customer surcharges designed to provide the full $200 million capped amount that PacifiCorp customers will contribute toward dam removal under the KHSA. PacifiCorp has collected dam removal surcharges from Oregon customers since March 2010 and began collecting surcharges from California customers in January 2012.

The Oregon customer surcharge, with accrued interest, is designed to provide approximately $184 million for dam removal in 2020. The California surcharge, with accrued interest, is designed to provide approximately $16 million in funding for dam removal in 2020. Together, the trust accounts had a balance of $75.5 million as of May 31, 2014.

Interim Measures

PacifiCorp continues to implement the interim measures in the KHSA to address environmental conditions and improve fisheries during the period prior to dam removal.

The company is funding several water quality-related initiatives and studies, including basin-wide water quality monitoring and studies intended to reduce nutrient levels in the Klamath River and improve water quality in the Project reservoirs. Other ongoing actions include operational adjustments to Project operations and the implementation and funding of fish habitat improvements within the Project and in the Klamath basin below Iron Gate dam. Under terms of the settlement, PacifiCorp is also now fully funding the ongoing operations of Iron Gate Hatchery and the implementation of a Hatchery and Genetics Management Plan to aid in the conservation and recovery of coho salmon.

PacifiCorp is pleased with the progress made in implementing the KHSA and the various interim measures that will result in improvements to water quality, fish habitat, and other environmental improvements. PacifiCorp notes the significant contributions of KHSA parties, tribes, and involved state and federal agencies in these efforts and looks forward to working with our stakeholders as these efforts continue to move forward.

Contents

Figure

1.0 Introduction

On February 18, 2010, PacifiCorp, along with representatives of more than 40 organizations, including Federal agencies, the States of California and Oregon, Native American tribes, counties, irrigators and conservation and fishing groups signed the historic Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA lays out the process for additional studies, environmental review, and a decision by the Secretary of the Interior regarding whether removal of four Klamath River dams owned by PacifiCorp should proceed. The four Klamath River dams proposed to be removed are J.C. Boyle, Copco No. 1, Copco No. 2 and Iron Gate. The KHSA includes provisions for the interim operation of the dams until their anticipated removal in 2020 and spells out the process to transfer, decommission, and remove the dams. The KHSA also contains a set of interim measures that PacifiCorp is implementing during the period prior to potential dam removal to improve water quality and fish habitat conditions, support and improve hatchery operations, and benefit environmental resources in the Klamath basin. A copy of the KHSA can be found on PacifiCorp's website at:

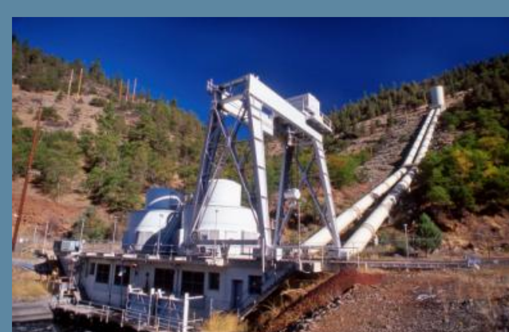
http://www.pacificorp.com/es/hydro/hl/kr.html

Since the execution of the KHSA, PacifiCorp has been working diligently in cooperation with parties to the KHSA and other affected stakeholders and regulatory agencies to implement its obligations under the KHSA and advance the settlement process. The purpose of this annual report is to document the progress made in implementing the KHSA.

Iron Gate Dam and Powerhouse

Copco No. 2 Dam

Copco No. 1 Dam and Powerhouse



J.C. Boyle Powerhouse

1.1 Background

PacifiCorp owns and operates the Klamath Hydroelectric Project (Project), located on the upper Klamath River in Klamath County (south-central Oregon) and Siskiyou County (north-central California). The Project consists of eight developments, as shown in Figure 1. Seven of the developments are located on the Klamath River between river mile (RM) 190.1 and 254.3, including (in order moving upstream) Iron Gate (RM 190.1 to 196.9), Copco No. 2 (RM 198.3 to 198.6), Copco No. 1 (RM 198.6 to 203.1), J.C. Boyle (RM 220.4 to 228.3), Keno (RM 233 to 253.1), East Side and West Side (both in Link River at RM 253.1 to 254.3). The eighth development is on Fall Creek, a Klamath River tributary at RM 196.3. The Project is licensed by the Federal Energy Regulatory Commission as Project No. 2082. With the exception of Fall Creek, the Project is largely dependent on water releases from Upper Klamath Lake at the U.S. Bureau of Reclamation's (Reclamation) Link River dam (RM 254.3).

On February 25, 2004, PacifiCorp filed an application with the Federal Energy Regulatory Commission (FERC) for a new 50-year license for the Project. PacifiCorp proposes in its application to operate five of the developments in a manner similar to current operations with a set of environmental measures, the purposes of which include (but are not limited to) water quality and habitat enhancement, instream flows and ramp rates[1] management, facilitation of fish passage, and enhancement of Iron Gate Hatchery stock management.

Following the submittal of its application for a new license, PacifiCorp began settlement discussions with a diverse group of stakeholders to resolve issues related to relicensing of the Project. PacifiCorp worked collaboratively with this group of stakeholders to develop and enter into the KHSA. A precursor to the KHSA, the Klamath Agreement in Principle (AIP) laid out a framework for the KHSA and was signed on November 13, 2008.

After five years of negotiations, the KHSA was signed by the involved parties on February 18, 2010 and identifies a process and path forward that provides for the decommissioning and removal of Iron Gate, Copco No. 2, Copco No. 1, and J.C. Boyle dams in 2020, subject to certain contingencies including funding, the passage of federal legislation, and a determination by the Secretary of the Interior that removal of the dams should proceed. Specifically, the Secretary will determine whether removal of PacifiCorp's lower four dams on the Klamath River 1) will advance restoration of the salmonid fisheries of the Klamath Basin; and 2) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and tribes.

PacifiCorp agreed to a potential dam removal path for the Project and executed the KHSA based upon an assessment that the KHSA provided superior cost and risk protections for PacifiCorp and its customers as compared to continuing on a path of relicensing the Project. Under the KHSA, PacifiCorp's customers in California and Oregon will be assessed surcharges to provide up to $200 million in funding towards dam removal costs. The State of California is to provide up to $250 million in funding for dam removal costs in excess of the $200 million Customer Contribution.

If the Secretary of the Interior issues a determination to proceed with dam removal, and the states of California and Oregon concur with that determination, PacifiCorp will transfer the four Klamath River dams to be removed to a Dam Removal Entity (DRE). The DRE is to be designated by the Secretary of the Interior as part of the Secretarial Determination process. The DRE will be responsible for obtaining necessary permits, contracts, insurance, and

[1] Hydroelectric facilities typically have the capability of increasing and decreasing flow levels downstream of the facilities. In general, the rate at which these flow changes occur is called the "ramp rate" or "ramping."

other authorizations to complete removal of the facilities. Keno dam, which is owned by PacifiCorp, will continue to serve irrigation purposes and is to be transferred to Reclamation.

The current FERC license for the Project expired on March 1, 2006, and the Project is now operating under annual licenses from FERC pending final resolution of the FERC licensing process as may be amended by legislation implementing the KHSA. It is anticipated that the Project will continue operating under annual licenses until the dams are removed pursuant to the KHSA or a new license is issued. The KHSA provides that Project operations will continue over the interim period until the dams are removed or, should dam removal not proceed, until a new license is issued. Should the Secretary of the Interior determine that dam removal should not proceed, or the KHSA terminates for other reasons, the FERC relicensing process for the Project would resume. The KHSA also provides that a new FERC license will not be issued and the licensing process will be held in abeyance pending the outcome of the Secretarial Determination and, should the Secretary render an affirmative determination, during the interim period prior to dam removal.

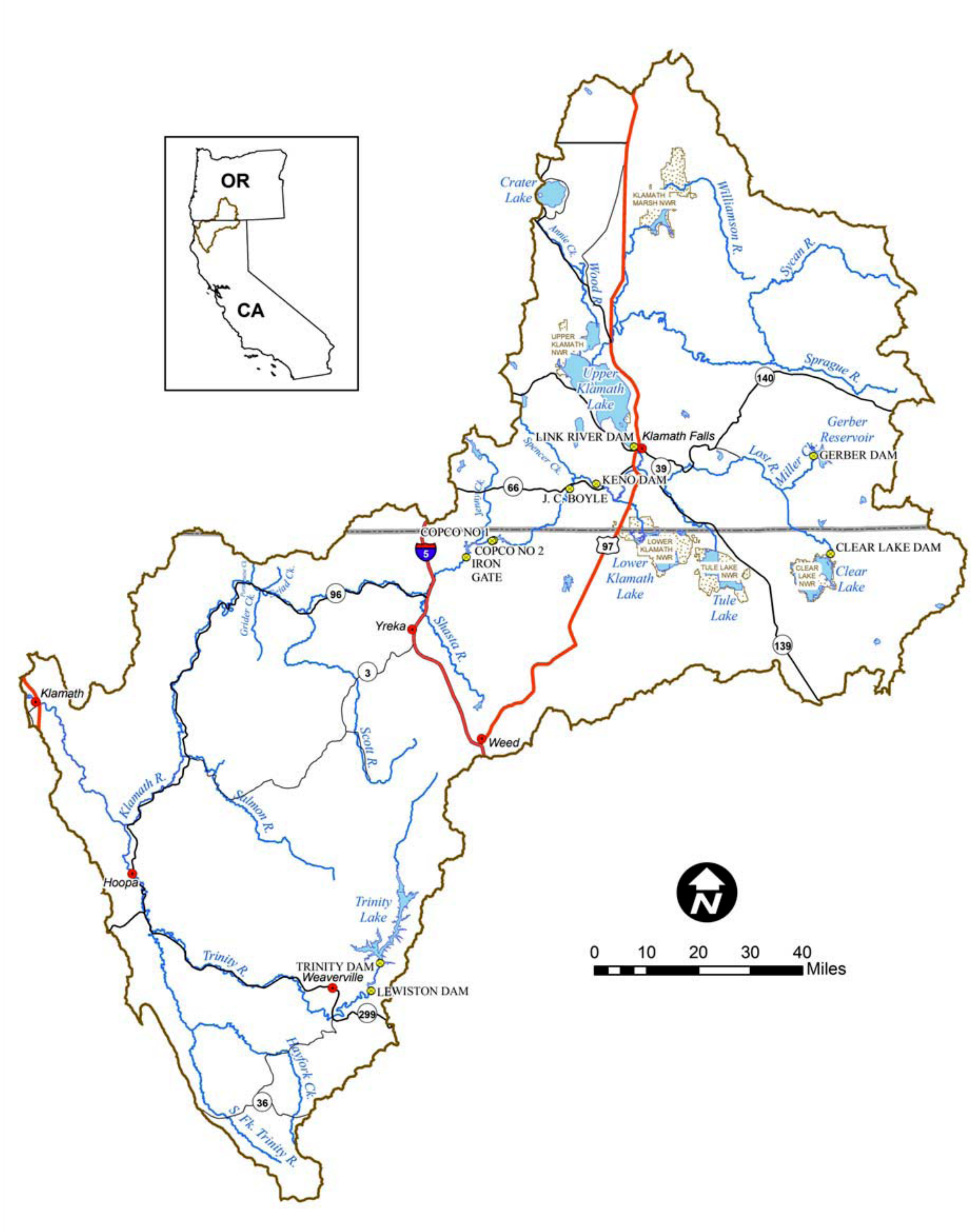


Figure 1

Klamath Basin Map

2.0 Parties to the Klamath Hydroelectric Settlement Agreement

The parties to the KHSA are listed below.

United States

The United States Department of Commerce, National Marine Fisheries Service

The United States Department of the Interior, including:

- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Fish and Wildlife Service

State of California

California Department of Fish and Wildlife
California Natural Resources Agency

State of Oregon

Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife
Oregon Water Resources Department

PacifiCorp

Tribes

Karuk Tribe
Klamath Tribes
Yurok Tribe

Counties

Humboldt County, California
Klamath County, Oregon

Parties Related to Klamath Reclamation Project

Ady District Improvement Company
Collins Products, LLC

Enterprise Irrigation District
Don Johnston & Son
Inter-County Properties Co, which acquired title as Inter-County Title Company
Klamath Irrigation District
Klamath Drainage District
Klamath Basin Improvement District
Klamath Water Users Association
Klamath Water and Power Agency
Bradley S. Luscombe
Malin Irrigation District
Midland District Improvement Company
Pioneer District Improvement Company
Plevna District Improvement Company
Reames Golf and Country Club
Shasta View Irrigation District
Sunnyside Irrigation District
Tulelake Irrigation District
Van Brimmer Ditch Company
Randolph and Jane Walthall 1995 Trust
Westside Improvement District #4
Winema Hunting Lodge, Inc.

Upper Klamath Irrigators

Upper Klamath Water Users Association

Non-Governmental Organizations

American Rivers
California Trout
Institute for Fisheries Resources
Northern California/Nevada Council Federation of Fly Fishers
Pacific Coast Federation of Fishermen's Associations
Salmon River Restoration Council
Trout Unlimited

3.0 Funding

The KHSA sets out a cost cap for facilities removal of $450 million. Of this amount, up to $200 million is to come from surcharges on PacifiCorp's customers in California and Oregon. In addition, the State of California will fund up to $250 million in dam removal costs in excess of the customer cost cap through the sale of bonds or another appropriate state financing mechanism.

3.1 Customer Contributions

3.1.1 Oregon Public Utility Commission Proceedings

On March 18, 2010, in accordance with KHSA Sections 4.1.1 and 7.3.9, PacifiCorp filed its analyses of the rate-related costs, benefits and risks to customers of the KHSA as compared to relicensing the Klamath River dams with the Oregon Public Utility Commission. This filing, with supporting testimony, was an application to implement provisions of Oregon Senate Bill 76 passed in the 2009 Oregon legislative session. PacifiCorp concurrently filed an advice letter establishing two surcharges, effective upon filing, to collect the customer contribution towards dam removal costs. In its application, PacifiCorp also requested that the depreciation schedule for Project facilities be adjusted in contemplation of their anticipated removal in 2020 and sought authorization to transfer Project facilities to the Dam Removal Entity. On September 16, 2010, the Oregon Public Utility Commission (OPUC) issued a final order affirming the dam removal surcharges for Oregon customers and a depreciation schedule for the facilities that provides for removal in 2020. The OPUC order requires PacifiCorp to seek authorization to transfer Project facilities to the DRE at a later date. The OPUC order is available at:

http://apps.puc.state.or.us/orders/2010ords/10-364.pdf

Since the surcharges commenced in March 2010, PacifiCorp has been remitting collected surcharges to trust accounts established by the OPUC with an independent financial institution. As of May 31, 2014, the balance of the Oregon customer dam removal trust accounts was as follows:

J.C. Boyle Trust Account	$17,429,332.96
Copco 1, Copco 2, and Iron Gate Trust Account	$52,525,681.61
Total	**$69,955,014.57**

The Oregon customer surcharges, with accrued interest, are designed to provide approximately $184 million in funding for dam removal in 2020.

3.1.2 California Public Utilities Commission Proceedings

On March 18, 2010, in accordance with KHSA Sections 4.1.1 and 7.3.9, PacifiCorp filed an application requesting authorization to begin collecting dam removal surcharges from its California customers and seeking authorization to transfer Project facilities to the Dam Removal Entity. This application included supporting testimony regarding the rate-related costs, benefits and risks to customers of the KHSA as compared to relicensing. In its application, PacifiCorp also requested that the depreciation schedule for Project facilities be adjusted in contemplation of their anticipated removal in 2020. On May 6, 2011, the California Public Utilities Commission (CPUC) issued a final decision approving 1) the request for a surcharge of $13.76 million collected over nine years; 2) institution of two trust accounts for the deposit of the surcharge; and 3) depreciation of the rate base of the Klamath River Project assets, and amortization of the relicensing and settlement costs associated with the Klamath River Project, on an accelerated basis. On June 6, 2011, PacifiCorp filed an advice letter requesting approval of revised tariffs adding the Klamath Surcharge. The trust accounts were established with an independent financial institution by the CPUC in January 2012 and PacifiCorp began assessing the surcharge on January 10, 2012.

Due to a delay between the issuance of the decision and the establishment of the trust accounts, approximately eight months of collecting the surcharge were lost. On January 13, 2012, PacifiCorp filed a request to increase the Klamath surcharge rate in order to collect the full amount of the surcharge within the original collection timeframe. The Commission approved PacifiCorp's request on October 25, 2012 and new rates became effective October 29, 2012.

The CPUC final decision is available at:

http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/134812.htm

As of May 31, 2014, the balance of the California customer dam removal trust accounts was as follows:

J.C. Boyle Trust Account	$885,716.31
Copco 1, Copco 2, and Iron Gate Trust Account	$2,671,151.97
Total	**$3,556,868.28**

The California customer surcharges, with accrued interest, are designed to provide approximately $16 million in funding for dam removal in 2020.

3.1.3 Total Trust Account Balances

The total balance of the California and Oregon dam removal trust accounts maintained by independent financial institutions under the direction of the California and Oregon public utility commissions was $73,511,882.85, as of May 31, 2014.

3.1.4 Management of the Trust Accounts

Pursuant to KHSA Section 4.2.4, the public utility commissions in California and Oregon have entered into trust management agreements with independent financial institutions to manage the trust accounts established to hold the dam removal surcharges that constitute the Customer Contribution towards dam removal costs. Disbursement of funds to the dam removal entity for permitting and facilities removal expenditures will occur at the direction of authorized representatives of the public utility commissions.

3.2 State of California Funding

If the cost of facilities removal exceeds the $200 million Customer Contribution, then the State of California is to provide funding of up to $250 million to cover the additional costs. Consistent with KHSA Section 4.1.2, this funding may come from a California Bond Measure or other appropriate state financing mechanism.

On November 4, 2009, the California Legislature voted to place an $11.1 billion water bond measure, including funding of up to $250 million for Klamath River dam removal and related measures, on the ballot for November 2010. The California Legislature subsequently withdrew the bond measure from voter consideration on August 9, 2010, deferring the bond to the November 2012 California ballot. The bond measure was then deferred to the November 2014 ballot by California Assembly Bill No. 1422, chaptered into law on July 9, 2012.

4.0 Federal Legislation

On May 21, 2014, Senators Wyden, Merkley, Boxer and Feinstein introduced Senate bill S. 2379 which would endorse the Klamath Hydroelectric Settlement Agreement, the Klamath Basin Restoration Agreement (KBRA), and the Upper Basin Comprehensive Agreement (Comprehensive Agreement). The Comprehensive Agreement was finalized in March, 2014 and provides the framework for a settlement of water rights claims between the Klamath Tribes, the Bureau of Indian Affairs and Off-Project irrigators in the Upper Klamath Basin. The Comprehensive Agreement was envisioned by the KBRA and with its execution in early 2014 the Klamath Settlements in their entirety can be considered by Congress and enacted through S. 2379.

On June 3, 2014, the Senate Energy and Natural Resources Committee held a hearing to receive testimony on the proposed legislation and the recently executed Comprehensive Agreement.

If legislation is approved by Congress and consistent with the KHSA, the Secretary of the Interior will determine whether to proceed with removal of the Klamath Hydroelectric Project facilities based on the unique standard and procedures set forth in the KHSA. The non-federal parties to the KHSA, KBRA, and Comprehensive Agreement continue to work with the Congressional delegations from Oregon and California in support of enactment of legislation to implement the Klamath Settlements.

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

II

113TH CONGRESS
2D SESSION

S. 2379

To approve and implement the Klamath Basin agreements, to improve natural resource management, support economic development, and sustain agricultural production in the Klamath River Basin in the public interest and the interest of the United States, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 21, 2014

Mr. WYDEN (for himself, Mr. MERKLEY, Mrs. FEINSTEIN, and Mrs. BOXER) introduced the following bill; which was read twice and referred to the Committee on Energy and Natural Resources

A BILL

To approve and implement the Klamath Basin agreements, to improve natural resource management, support economic development, and sustain agricultural production in the Klamath River Basin in the public interest and the interest of the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Klamath Basin Water Recovery and Economic Restoration Act of 2014".

SEC. 2. DEFINITIONS.

In this Act:

5.0 Studies, Environmental Review, and Secretarial Determination

As described in Section 3 of the KHSA, the Secretary of the Interior, in cooperation with the Secretary of Commerce and other Federal agencies, is conducting studies and environmental review to determine whether to proceed with facilities removal. The Secretary of the Interior will determine whether, in his judgment, facilities removal 1) will advance restoration of the salmonid fisheries of the Klamath Basin; and 2) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and tribes.

This environmental review and study process is being conducted consistent with the National Environmental Policy Act (NEPA) and the State of California is conducting review under the California Environmental Quality Act (CEQA). Public NEPA scoping for the Secretarial Determination process was conducted during summer 2010 and numerous public meetings regarding the Agreements and the environmental review process have been held within local Klamath basin communities.

On April 4, 2013, the Department of the Interior (Interior) released a Final Klamath Facilities Removal Environmental Impact Statement (Final EIS). The Final EIS identifies effects of the proposed action (dam removal and implementation of the KBRA) as well as other alternatives analyzed. The Final EIS identifies full removal of all four mainstem PacifiCorp hydroelectric facilities (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) as the preferred alternative to achieve a free flowing river and realize other goals and objectives expressed in the Klamath Basin Restoration Agreement and the Klamath Hydroelectric Settlement Agreement. The matter now awaits congressional action which is necessary to authorize the Secretary of the Interior to make a determination whether the removal of the four facilities should proceed.

Information on the NEPA process, the Final EIS, and the related environmental studies can be found at the website KlamathRestoration.gov.

PacifiCorp has fully cooperated with relevant federal and state agencies in the environmental review and study process, and the development, by Interior, of the detailed plan for facilities removal. This cooperative effort has involved the transfer of project-related engineering design and operational information to allow the development of engineering designs and planning documents necessary to develop the detailed plan, and sediment sampling on and around Project reservoirs as well as many other activities to allow the Department of the Interior to develop necessary information for the Secretarial Determination process.

The detailed plan for facilities removal includes the following elements:

- The physical methods to be undertaken to remove the four mainstem hydroelectric dams, including a timetable;
- Plans for the management, removal, and/or disposal of sediment, debris and other materials;
- A plan for site remediation and restoration; and
- A detailed statement of the estimated costs of facilities removal as contemplated in the KHSA.

Interior's cost estimates contained in the detailed plan indicate the most probable cost of measures to implement full facilities removal is $292 million, which is less than the $450 million cost cap for facilities removal contained in the KHSA. These cost estimates also indicate that the State of California's contribution towards the cost of facilities removal through a bond measure or other financing mechanism may be less than $250 million.

6.0 Interim Operations

6.1 Lease of State-Owned Beds and Banks

Pursuant to KHSA Section 2.5, PacifiCorp and the State of Oregon executed leases for J.C. Boyle and Keno dams in June 2011 and PacifiCorp is complying with the terms of those leases and remitting lease payments to the State of Oregon.

6.2 Keno Transfer

Pursuant to KHSA Section 7.5.2, PacifiCorp and the Department of the Interior, Bureau of Reclamation (Reclamation) executed an Agreement in Principle regarding the potential transfer of the Keno development to Reclamation in August, 2012. The Agreement in Principle memorializes broad principles designed to function as a framework for the development of a final agreement for PacifiCorp to transfer the Keno Facility to Interior. PacifiCorp and Interior continue good-faith negotiations to reach a final Transfer Agreement consistent with the principles outlined in the Agreement in Principle prior to the Secretarial Determination. The final Transfer Agreement will outline exactly how necessary lands and improvements will be transferred to Interior as specified in the KHSA and details related to ongoing access to affected lands and provisions for the transfer of control of the facility from PacifiCorp to Interior.

Keno Dam

6.3 Local Community Power

Pursuant to Section 5.3, representatives of Interior, PacifiCorp, the Klamath Water and Power Agency (KWAPA), Klamath Water Users Association (KWUA), Bonneville Power Administration, and the Western Area Power Administration have held numerous meetings regarding the development and implementation of a federal power program that would provide federal power to eligible Klamath basin irrigation loads.

PacifiCorp has transferred customer load information to KWAPA for customers that have indicated an interest in the program and signed releases authorizing the release of their customer information to KWAPA. This customer load data is informing KWAPA and Interior's planning for the delivery of federal power to serve eligible loads and estimated costs associated with the program.

PacifiCorp has assisted KWAPA and its consultants to develop an analysis of the potential cost savings associated with implementation of the federal power program. PacifiCorp continues to work cooperatively with the involved parties to advance the power provisions of the Klamath Settlements, which are an important element of the KHSA for Klamath basin irrigators who are now paying higher power rates under tariffs approved by the public utility commissions.

6.4 Section 401 Water Quality Certification Process

Section 6.5 of the KHSA commits the KHSA parties to request abeyance of the California and Oregon Clean Water Act Section 401 water quality certification process for PacifiCorp's relicensing application, pending completion of the Secretarial Determination process and during the interim period prior to potential dam removal. Given the anticipated removal of the hydroelectric project facilities in 2020, abeyance of the 401 process relieves the states, PacifiCorp, and other interested parties of the burden of processing relicensing certification applications during the interim period prior to dam removal pursuant to the KHSA while preserving the full authority of the states to condition the Project through the 401 certification process should dam removal under the KHSA not occur and the relicensing process resume.

Under the KHSA, PacifiCorp has been funding and implementing various water quality-related interim measures that are intended to improve the understanding of basin-wide water quality issues in the Klamath River and work towards identifying solutions that may improve water quality conditions prior to dam removal as well as following potential removal of PacifiCorp's dams. Specific water quality-related interim measures include turbine venting at Iron Gate dam to improve dissolved oxygen concentrations in the Klamath River (Interim Measure No. 3), funding for a water quality technical workshop to investigate solutions to address Klamath River nutrient impairment (Interim Measure No. 10), and ongoing studies and pilot projects being implemented now to improve water quality and inform the planning and development of additional projects to improve Klamath basin water quality conditions (Interim Measure No. 11), as well as comprehensive basin-wide water quality monitoring to support dam removal permitting studies, nutrient removal projects, and public health monitoring (Interim Measure 15).

On March 19, 2010, PacifiCorp requested, on behalf of the Parties except the Oregon Department of Environmental Quality (ODEQ), that the California State Water Resources Control Board (SWRCB) and ODEQ hold in abeyance permitting and environmental review for PacifiCorp's relicensing during the Interim Period. This request was subsequently granted by ODEQ on March 29, 2010 and the SWRCB passed a resolution granting the abeyance, with conditions, on May 18, 2010.

The SWRCB's abeyance resolution expired in June 2013 and since that time PacifiCorp has undertaken modifications to its 401 applications, in consultation with State Water Resources Control Board staff, to incorporate relevant technical information and the results of ongoing water quality studies into its certification application.

As required by the KHSA, PacifiCorp withdraws and resubmits its application for Section 401 certification from California and Oregon to preserve the authority of the states to issue Section 401 certifications should there be a return to the relicensing process. This practice ensures that there is no waiver of certification as a result of the focus of the KHSA parties on successful implementation of the KHSA. PacifiCorp most recently withdrew and resubmitted its requests for Section 401 certification from California and Oregon on December 2, 2013.

6.5 TMDLs

Pursuant to KHSA Section 6.3, PacifiCorp filed a "Plan for Implementing Management Strategies and Water Quality-Related Measures" with the Oregon Department of Environmental Quality and the North Coast Regional Water Quality Control Board on February 22, 2011. PacifiCorp's submittal of this plan was triggered under the KHSA by the NCRWQCB's approval of the "Klamath River Total Maximum Daily Load" (TMDL) on September 7, 2010 and by the Oregon Department of Environmental Quality's issuance of the "Upper Klamath and Lost River Subbasins Total Maximum Daily Load" on December 21, 2010. These plans specify the interim water quality measures that PacifiCorp will implement prior to potential transfer of the Project to the Dam Removal Entity in 2020.

7.0 Interim Measures Implementation

7.1 Interim Measures Implementation Committee Meeting Dates and Members

7.1.1 Purpose and Goals of the Interim Measures Implementation Committee

The purpose of the Interim Measures Implementation Committee (IMIC) is to collaborate with PacifiCorp on ecological and other issues related to the implementation of the Interim Measures set forth in Appendix D of the KHSA. The primary goals of the IMIC are: (i) to achieve consensus where possible; and (ii) timely implementation of the matters within the scope of the IMIC's responsibilities under the KHSA.

The IMIC meets quarterly and members can attend in person or via a conference line. These meetings typically consist of a technical review of study plans, updates on Interim Measure study progress, and review of technical reports. Since January 2013, the IMIC has agreed to hold its quarterly meetings in Yreka, California, which is a central location for most members.

Between June 2013 and June 2014, 4 meetings were held; two in 2013 (July 18 and October 16) and two in 2014 (January 16 and April 16). Representatives to the IMIC are shown in the following table.

7.1.2 IMIC Representatives

IMIC Member	Organization
John Hamilton	U.S. Fish and Wildlife Service
Mike Belchik	Yurok Tribe
Susan Corum	Karuk Tribe
Rick Carlson	Bureau of Reclamation
Donna Cobb	California Department of Fish and Wildlife
Clayton Creager	North Coast Regional Water Quality Control Board
Gary Curtis	California Department of Fish and Wildlife
Larry K. Dunsmoor	The Klamath Tribes
Micah Gibson	Yurok Tribe
Kyle Gorman	Oregon Water Resources Department
Mary Grainey	Oregon Water Resources Department
Chelsea Aquino	Bureau of Land Management
Mark Hampton	National Marine Fisheries Service
Tim Hemstreet	PacifiCorp
Nick Hetrick	U.S. Fish and Wildlife Service
Robert M. Hooton	Oregon Department of Fish and Wildlife
Curtis Knight	California Trout

IMIC Member	Organization
Linda Prendergast	PacifiCorp
Erin Ragazzi	California State Water Resources Control Board
Mark Rockwell	Federation of Fly Fishers, N. CA Council
Steve Rothert	American Rivers
Jim Simondet	National Marine Fisheries Service
Glen H. Spain	Institute for Fisheries Resources
Chris Stine	Oregon Department of Environmental Quality
Parker Thaler	California State Water Resources Control Board
Bill Tinniswood	Oregon Department of Fish and Wildlife
S. Craig Tucker	Karuk Tribe
Jane Vorpagel	California Department of Fish and Wildlife
Ted Wise	Oregon Department of Fish and Wildlife

7.2 Interim Conservation Plan Interim Measures and Endangered Species Act Regulatory Process

Section 6.2 of the KHSA provides as follows:

> ***PacifiCorp shall apply to the Services pursuant to ESA Section 10 and applicable implementing regulations to incorporate the Interim Conservation Plan measures, including both Appendix C (ICP Interim Measures) and the Interim Conservation Plan measures for protection of listed sucker species not included in Appendix C, into an incidental take permit.***

Since 2009, PacifiCorp has worked closely with the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS) to develop applications for ESA Section 10 permits consistent with agency regulations.

Coho Salmon Habitat Conservation Plan

In February, 2011, PacifiCorp filed an application for an ESA Section 10 permit with NMFS. The permit application developed with NMFS includes a Habitat Conservation Plan (HCP) that identifies a process to implement measures that will avoid, minimize and mitigate the effects of Project operations on coho salmon and attain the biological goals and objectives described in the HCP's coho conservation strategy. Such measures include 1) implementing habitat enhancement activities through a Coho Enhancement Fund, 2) implementing flow releases and turbine venting at Iron Gate dam to improve habitat conditions for coho salmon in the Klamath River, 3) funding research actions on Klamath River fish disease, 4) retrieval and passage of large wood debris trapped at PacifiCorp's facilities, and 5) monitoring to assess the benefits of these measures.

On February 24, 2012, NMFS issued a final Incidental Take Permit that authorizes potential incidental take of coho salmon that could occur as a result of PacifiCorp's interim operation of the Project consistent with the terms of the Habitat Conservation Plan. On April 30, 2012, PacifiCorp filed its first annual report with NMFS documenting activities undertaken in 2012 to implement the HCP. Activities conducted under the HCP to date include operational adjustments to improve dissolved oxygen in flow releases from Iron Gate powerhouse, the implementation of habitat enhancement projects to benefit coho salmon below Iron Gate dam funded through PacifiCorp's Coho Enhancement Fund, fish disease research, development of a hatchery and genetics management plan, delivery of flows from Iron Gate dam in support of Reclamation's regulatory requirements, and monitoring and adaptive management.

PacifiCorp also developed a Gravel Augmentation Plan as required by the HCP, which was submitted to NMFS for review and approved. Gravel augmentation immediately below Iron Gate dam is scheduled to occur in late summer 2014.

The HCP also requires water quality data collection and analysis. PacifiCorp submitted a final Water Quality Monitoring Plan to NMFS on February 24, 2013, including procedures to monitor water temperature and dissolved oxygen at designated monitoring sites. In May 2013, PacifiCorp completed arrangements with the U.S. Geological Survey (USGS) to install and collect continuous water temperature data in the Klamath River at Orleans. Since 2008, continuous monitoring of water temperature and dissolved oxygen has occurred i in the Klamath River below Iron Gate Dam. Data collected will be used to an Annual Water Quality Monitoring Report to be submitted to

Klamath River Coho Salmon

NMFS to evaluate consistency with the water quality objectives contained in the Coho HCP.

Sucker Habitat Conservation Plan

In August, 2011, PacifiCorp filed an application for an ESA Section 10 permit with USFWS, including a draft Habitat Conservation Plan, to address potential incidental take of sucker species that could occur during the interim period prior to Project removal. PacifiCorp submitted a revised Habitat Conservation Plan to USFWS in late 2012 and public comments on PacifiCorp's application were solicited in March 2013. On February 20, 2014 USFWS issued a final Incidental Take Permit that authorizes potential incidental take of listed suckers that could occur as a result of PacifiCorp's interim operation of the Project consistent with the terms of the Habitat Conservation Plan.

The Sucker HCP identifies a conservation strategy consisting of substantial shutdown of the East Side and West Side hydroelectric developments, continued support for an important restoration project on the Williamson River Delta, and a protocol for implementing a Sucker Conservation Fund that will avoid, minimize, and mitigate take of listed suckers.

7.3 Interim Measure 2: California Klamath Restoration Fund / Coho Enhancement Fund

PacifiCorp shall establish a fund to be administered in consultation with the California Department of Fish and Wildlife (after providing notice and opportunity for comment to the State Water Resources Control Board and North Coast Regional Water Quality Control Board) and NMFS to fund actions within the Klamath Basin designed to enhance the survival and recovery of coho salmon, including, but not limited to, habitat restoration and acquisition. PacifiCorp has provided $510,000 to this fund in 2009 and shall continue to provide this amount of funding annually by January 31 of each subsequent year in which this funding obligation remains in effect. Subject to Section 6.1.1, this funding obligation shall remain in effect until the time of decommissioning of all of the Facilities in California.

Off-Channel Pond Habitat construction

PacifiCorp has provided funding of $3,060,000 into the Coho Enhancement Fund since the Interim Conservation Plan was released in November, 2008. Since 2009, NMFS and CDFW have selected 24 projects to benefit coho salmon. PacifiCorp has developed a partnership with the National Fish and Wildlife Foundation (NFWF) to administer the fund. This partnership allows Coho Enhancement Fund grant recipients to be eligible for additional funding through other grant programs, further enhancing the conservation benefit of the fund. The recipients of Coho Enhancement Fund grants thus far are:

- Karuk Tribe: Seiad Creek Channel Restoration, Phase I, II and III: Engineering designs, permitting and stakeholder identification to realign Seiad Creek to a natural course to enable coho salmon potential year round habitat access.
- Mid Klamath Watershed Council: Seiad Creek Off-Channel Pond Habitat Construction.
- Siskiyou County Resource Conservation District: Fish Passage Improvement in the Scott River.
- Siskiyou County Resource Conservation District: Denny Ditch Fish Screen.
- Emmerson Investments: Shasta River Coho Habitat Project to conserve and enhance

more than 6 miles of Shasta river habitat with fencing as well as providing livestock stock water lanes.

- Grenada Irrigation District: Huseman Ditch point of diversion fish passage improvements allowing for 4.7 miles of instream cold water retention.
- Scott River Water Trust: Scott River water acquisition program enabling critical coho streams to remain connected to the Scott River. This project has gone through 2 award cycles.
- Mid Klamath Watershed Council: Coho Rearing Habitat Enhancement to create and restore more than 10 tributary cold water refugia areas at their confluences with the middle Klamath.
- Mid Klamath Watershed Council: Middle Klamath Restoration Prioritization Project to identify coho projects that will provide the greatest species benefit.
- Mid Klamath Watershed Council: Tributary Fish Passage Improvement Project to create fish passage at the mouths and in the lower reaches of 72 Mid Klamath Subbasin tributaries.
- Yurok Tribe: Lower Klamath Coho Habitat Enhancement and Monitoring for construction of an off-channel habitat feature in McGravey Creek, CA to increase juvenile coho salmon rearing capacity.
- Mid Klamath Watershed Council: Seiad/West Grider Coho Winter Rearing Habitat Project to create two off-channel ponds to improve winter habitat.
- Mid Klamath Watershed Council: Mid Klamath Coho rearing Habitat Enhancement Project to enhance habitat complexity.
- Caltrans District 2: Replace existing culvert on Fort Goff Creek and replace with a single-span bridge. Project will restore channel to provide coho fish passage and enhanced habitat.
- Mid Klamath Watershed Council: Stanshaw Creek water rights evaluation. This project will address limiting factors for coho salmon. This project has gone through 2 funding cycles.
- Mid Klamath Watershed Council: Tributary Coho Rearing Habitat Improvement. This project will create and/or enhance off-channel rearing and thermal refugia for coho salmon.
- Montague Water Conservation District: Shasta River Flow Augmentation Project.

  Yurok Tribe: Restoring Off-Estuary Habitat. This project will enhance habitat in the Lower Hoopaw Creek to benefit coho salmon.
- Mid Klamath Watershed Council: Mid Klamath Off-Channel Coho Rearing Habitat. This project will create approximately 22,000 square feet of critical off-channel winter and summer coho rearing habitat at 4 different locations.
- Scott River Watershed Council: Juvenile Coho Habitat Improvement using Beaver Dams. Beaver and beaver dam analogues will be used to improve the quantity and quality of coho rearing habitat in the Scott River and its tributaries.

A Technical Review Team was formed in 2012 and held its first meeting in June 2012. The Technical Review Team will meet annually to review existing projects funded under the Coho Enhancement Fund and to recommend possible adaptive management changes, if warranted, based, in part, on the results of monitoring data developed from funded projects.

7.4 Interim Measure 3: Iron Gate Turbine Venting

PacifiCorp shall implement turbine venting on an ongoing basis beginning in 2009 to improve dissolved oxygen concentrations downstream of Iron Gate dam. PacifiCorp shall monitor dissolved oxygen levels downstream of Iron Gate dam in 2009 and develop a standard operating procedure in consultation with NMFS for turbine venting

operations and monitoring following turbine venting operations in 2009.

Passive venting of the Iron Gate turbine was successfully tested at the Iron Gate powerhouse in the fall of 2008 and PacifiCorp installed a blower system at the Iron Gate powerhouse in January 2010 to enhance the effectiveness of turbine venting. The combined system was tested in 2010 and demonstrated an ability to significantly increase DO levels. PacifiCorp has been implementing turbine venting on an ongoing basis and developed a turbine venting Standard Operation Procedure (SOP) in early 2013 consistent with the terms of PacifiCorp's incidental take permit for coho salmon.

7.5 Interim Measure 4: Hatchery and Genetics Management Plan

Beginning in 2009, PacifiCorp shall fund the development and implementation of a Hatchery and Genetics Management Plan (HGMP) for the Iron Gate Hatchery. PacifiCorp, in consultation with the National Marine Fisheries Service and the California Department of Fish and Game, will develop an HGMP for approval by NMFS in accordance with the applicable criteria and requirements of 50 C.F.R. § 223.203(b)(5). To implement the HGMP, PacifiCorp, in consultation with NMFS and CDFG, will develop and agree to fund an adequate budget. When completed, CDFG shall implement the terms of the HGMP at Iron Gate Hatchery in consultation with PacifiCorp and NMFS. Funding of this measure is in addition to the 100 percent funding described in Non-ICP Interim Measure 18.

On September 16, 2010, a Hatchery and Genetic Management Plan (HGMP) for the Iron Gate Hatchery Coho Salmon Program was submitted to NMFS by CDFW following collaborative work among NMFS, CDFW and PacifiCorp to develop the application. The HGMP program will operate in support of the Klamath River basin's coho salmon recovery efforts by conserving a full range of the existing genetic, phenotypic, behavioral and ecological diversity of the coho salmon run.

The program's conservation measures, including genetic analysis, broodstock management, and rearing and release techniques, will maximize fitness and reduce straying of hatchery fish to natural spawning areas. In 2010, in cooperation with CDFW and NMFS, PacifiCorp began funding an active broodstock management program at Iron Gate Hatchery. The program is based on real-time genetic analysis of coho spawning broodstock and reduces the rate of inbreeding in the hatchery coho population that has occurred in the hatchery over time.

Additionally, changes have been made to increase the proportion of natural-origin fish in the total hatchery coho spawning population. These measures are anticipated to increase population diversity and fitness. Hatchery culture practices under the HGMP program are also being improved to increase egg-to-smolt survival rates by increasing survival during egg incubation and covering raceways with netting to reduce bird predation. In the fall of 2011, state-of-the-art moist-air incubators were installed at the hatchery as a measure to improve egg incubation survival.

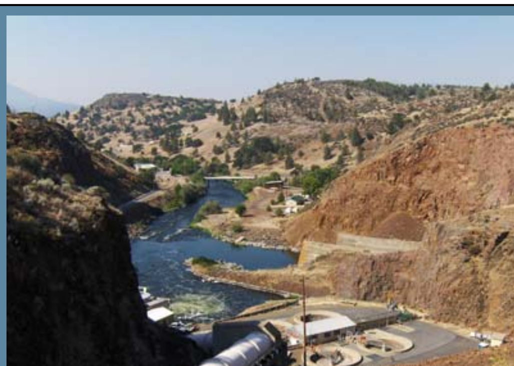
NMFS published the HGMP and associated documents in February, 2013 to solicit public review and comment to inform its evaluation of the HGMP and a decision about whether to approve the HGMP. The California Hatchery Scientific Review Group recommended that the Iron Gate HGMP be approved in its April 2012 report. The HGMP is under review and final approval by NMFS is expected in 2014.

7.6 Interim Measure 5: Iron Gate Flow Variability

In coordination with NMFS, USFWS, States and Tribes, PacifiCorp and Reclamation shall annually evaluate the feasibility of enhancing fall and early winter flow

variability to benefit salmonids downstream of Iron Gate Dam, subject to both PacifiCorp's and Reclamation's legal and contractual obligations. In the event that fall and early winter flow variability can feasibly be accomplished, PacifiCorp, in coordination with NMFS, USFWS, and Reclamation will, upon a final Incidental Take Permit issued to PacifiCorp by NMFS becoming effective, annually develop fall and early winter flow variability plans and implement those plans. Any such plans shall have no adverse effect on the volume of water that would otherwise be available for the Klamath Reclamation Project or wildlife refuges.

PacifiCorp has been implementing variable flow releases at Iron Gate dam consistent with the direction of the Bureau of Reclamation, in fulfillment of Term and Condition 2A of Reclamation's March 2010 Biological Opinion, resulting in several variable flow events in the fall and winter of 2012-2013 that have occurred as requested by Reclamation following the recommendations of a technical group including NMFS, Reclamation, PacifiCorp, USFWS, States, and Tribes.



Klamath River below Iron Gate Dam

The recently-issued joint biological opinion on Reclamation's Klamath Project for 2013-2023 includes provisions for more variable flow releases from Iron Gate dam to provide benefits to listed species. PacifiCorp works closely with Reclamation to coordinate river operations and dam releases in a manner that achieves Reclamation's flow requirements below Iron Gate dam while also meeting operational and other regulatory objectives of Reclamation and PacifiCorp.

In May, 2014, a pulse flow of 1,900 cfs was released from Iron Gate dam using water stored in PacifiCorp's hydroelectric reservoirs due to water supply limitations in the Upper Klamath Basin. The pulse flow was initiated in response to fish disease monitoring conducted in the Klamath River that indicated high disease loading. Fish disease researchers monitored disease conditions before, during, and after the pulse flow in order to better understand the relationships between flow and disease mechanisms in order to inform future management actions.

7.7 Interim Measure 6: Fish Disease Relationship and Control Studies

PacifiCorp has established a fund in the amount of $500,000 in total funding to study fish disease relationships downstream of Iron Gate Dam. Research proposals will be solicited and agreed upon by PacifiCorp and NMFS for the purpose of determining that the projects are consistent with the criteria and requirements developed by PacifiCorp and NMFS in the ESA review process applicable under Settlement Section 6.2. PacifiCorp will consult with the Klamath River Fish Health Workgroup regarding selection, prioritization, and implementation of such studies, and such studies shall be consistent with the standards and guidelines contained in the Klamath River Fish Disease Research Plan and any applicable recovery plans.

Humboldt State University, Oregon State University, and the Karuk and Yurok Tribes collaborated on a research proposal to examine how management actions could be focused to reduce the incidence of ceratomyxosis. Specific studies as part of the proposal include:

- Determine combinations of water hydraulics and sediment compositions that produce mortality in polychaetes;
- Measure the response of selected polychaete populations in the Klamath River to any experimental control actions over appropriate temporal and spatial scales;
- Determine the relative contribution of species-specific genotypes of *Ceratomyxa shasta* from tributary and mainstem sources and determine seasonal myxospore abundance; and
- Develop mathematical models to improve the understanding of *Ceratomyxa shasta* dynamics and provide opportunities for management (e.g., flow manipulations).

PacifiCorp and NMFS have agreed to appropriate money from the Fish Disease Fund to implement these studies. Results from these studies include several technical reports and a published journal article that are available on PacifiCorp's website under the Habitat Conservation Plan tab.

7.8 Interim Measure 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement

Beginning on the Effective Date and continuing through decommissioning of the J.C. Boyle Facility, PacifiCorp shall provide funding of $150,000 per year, subject to adjustment for inflation as set forth in Section 6.1.5 of the Settlement, for the planning, permitting, and implementation of gravel placement or habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir. Within 90 days of the Effective Date, PacifiCorp, in consultation with the IMIC, shall establish and initiate a process for identifying such projects to the Committee, and, upon approval of a project by the Committee, issuing a contract or providing funding to a third party approved by the Committee for implementation of the project. The objective of this Interim Measure is to place suitable gravels in the J.C. Boyle bypass and peaking reach using a passive approach before high flow periods, or to provide for other habitat enhancement providing equivalent fishery benefits in the Klamath River above Copco Reservoir. Projects undertaken before the Secretarial Determination shall be located outside the FERC project boundary.

The IMIC and PacifiCorp collaborated on the development a gravel enhancement plan and a monitoring plan, which serves as a basis for ongoing implementation actions under this interim measure.

Gravel Augmentation in the J.C. Boyle Reach of the Klamath River

Since access to the river to implement this measure will occur on BLM roads, the BLM conducted a NEPA analysis to assess potential impacts from implementation of this interim measure. The BLM issued a Finding of No Significant Impact (FONSI) in October 3, 2011.

Since 2011, approximately 1,600 cubic yards of gravel has been added to six sites in the Klamath River below J.C. Boyle dam. Monitoring is being conducted and additional gravel placement is scheduled to occur in October 2014.

7.9 Interim Measure 8: J.C. Boyle Bypass Barrier Removal

Within 90 days of the Effective Date, PacifiCorp, in consultation with the

Committee, shall commence scoping and planning for the removal of the sidecast rock barrier located approximately 3 miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle bypass reach. Upon Concurrence, and in accordance with a schedule approved by the Committee, PacifiCorp shall obtain any permits required for the project under Applicable Law and implement removal of the barrier. If blasting will be used, PacifiCorp shall coordinate with ODFW to ensure the work occurs during the appropriate in-water work period. The objective of this Interim Measure is to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout.

PacifiCorp worked with the IMIC to scope the bypass barrier removal and with the Bureau of Land Management to evaluate the effects of the project, which resulted in a Finding of No Significant Impact. With necessary permitting completed, PacifiCorp undertook the removal of the potential barrier on October 22, 2012 during the agency-approved in-water work period. The barrier was removed using a snatch block rigging system to remove rocks and boulders from the river channel above the high water line to create unimpeded fish passage. USFWS, NMFS, BLM and ODFW reviewed the photos, and depth and velocity measurements taken once the barrier was removed and have agreed that the fish passage concern has been resolved.

Copco Dam

7.10 Interim Measure 9: J.C. Boyle Powerhouse Gage

Upon the Effective Date, PacifiCorp shall provide the U.S. Geological Survey (USGS) with continued funding for the operation of the existing gage below the J.C. Boyle Powerhouse (USGS Gage No. 11510700). Funding will provide for continued real-time reporting capability for half-hour interval readings of flow and gage height, accessible via the USGS website. PacifiCorp shall continue to provide funding for this gage until the time of decommissioning of the J.C. Boyle Facility.

PacifiCorp is continuing to provide the USGS with funding for the operation of the existing gage below the J.C. Boyle powerhouse (USGS Gage No. 11510700). This gage data is available at: http://waterdata.usgs.gov/usa/nwis/uv?site_no=11510700.

7.11 Interim Measure 10: Water Quality Conference

PacifiCorp shall provide one-time funding of $100,000 to convene a basin-wide technical conference on water quality within one year from the Effective Date of this Settlement. The conference will inform participants on water quality conditions in the Klamath River basin and will inform decision-making for Interim Measure No. 11, with a focus on nutrient reduction in the basin including constructed wetlands and other treatment technologies and water quality accounting. PacifiCorp, the North Coast Regional Water Quality Control Board, and the Oregon Department of Environmental Quality, will convene a steering committee to develop the agenda and panels.

PacifiCorp, the NCRWQCB and ODEQ formed a steering committee to organize the workshop, which was conducted from September 11-13, 2012 in Sacramento, California. The goal of the workshop was to inform participants on water quality conditions in the Klamath River basin and engage invited experts and managers to evaluate large-scale nutrient and organic matter reduction technologies for application in the Klamath basin. The NCRWQCB has taken the lead on the steering committee and the California Coastal Conservancy matched PacifiCorp's funding to assist with workshop planning and pre-and- post workshop reports. A consultant team has been hired to develop these report materials. The workshop was held on September 11-13, 2012 in Sacramento, California with over 100 invited participants attending. A report on the outcomes from the workshop activities is available at: http://www.stillwatersci.com/case_studies.php?cid=68).

7.12 Interim Measure 11: Interim Water Quality Improvements

The purpose of this measure is to improve water quality in the Klamath River during the Interim Period leading up to dam removal. The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir. Upon the Effective Date of the Settlement until the date of the Secretarial Determination, PacifiCorp shall spend up to $250,000 per year to be used for studies or pilot projects developed in consultation with the Implementation Committee regarding the following:

- ***Development of a Water Quality Accounting Framework***
- ***Constructed Treatment Wetlands Pilot Evaluation***
- ***Assessment of In-Reservoir Water Quality Control Techniques***
- ***Improvement of J.C. Boyle Reservoir Dissolved Oxygen***

By the date of the Secretarial Determination, PacifiCorp shall develop a priority list of projects in consultation with the Implementation Committee. The priority list will be informed by, among other things, the information gained from the specific studies conducted before the Secretarial Determination and the information generated at the water quality conference specified in Interim Measure 10. Should the Secretary of Interior render an Affirmative Determination, PacifiCorp shall provide funding of up to $5.4 million for implementation of projects approved by the Oregon Department of Environmental Quality (ODEQ) and the State and Regional Water Boards, and up to $560,000 per year to cover project operation and maintenance expenses related to those projects, these amounts subject to adjustment for inflation as set forth in Section 6.1.5 of this Settlement. Recognizing the emphasis on nutrient reduction projects in the watershed while also seeking to improve water quality conditions in and downstream of the Project during the Interim Period, the Parties agree that up to 25 percent of the funding in this measure for pre- Secretarial Determination studies and post-Secretarial Determination implementation may be directed towards in-reservoir water quality improvement measures, including but not limited to J.C. Boyle.

Consistent with the intent of this interim measure, studies are being conducted to address Klamath River nutrient reduction while also addressing water quality issues in Project reservoirs. Work on the study plans and draft technical reports on the studies are prepared for the IMIC to review. After review and responding to comments from the IMIC, work plans for water quality studies and technical reports are finalized. The studies that have been pursued to date through Interim measure 11 are described fully below.

7.12.1 Evaluation of Treatment by Wetlands

This study includes the following tasks: 1) use of wetland design tools to provide estimates of wetland size requirements to achieve nutrient load reductions at various assumed levels (including levels required in the TMDL); 2) an assessment of pretreatment methods options to enhance the effectiveness of a constructed treatment wetland; and 3) identification of logical next steps to more specifically ascertain the types, sizes, configurations, and locations of potential treatment wetlands. A draft report was distributed to the IMIC for review in March 2012. The report presents detailed information on the applicability of wetlands to address Klamath River nutrient impairment and presents several potential supplemental technologies to enhance treatment by wetlands. These technologies include constructed emergent vegetation surface flow wetland systems, submerged aquatic vegetation systems, periphyton-based treatment systems, various supplemental chemical treatment approaches, and systems combining chemical, settling and solids separation, and filtration. Each of these supplemental technologies are described, including their relative effectiveness, advantages and disadvantages, costs, and potential for application in the Upper Klamath basin.

A presentation of study results was provided to the IMIC in April 2011 and a final report was released in August 2012, which is available on PacifiCorp's website. The final report has informed discussions of constructed wetlands treatment as a tool to reduce Klamath River nutrient concentrations in the water quality workshop, to which PacifiCorp provided funding under Interim Measure 10.

7.12.2 Evaluation of Organic Matter Removal for Keno Reservoir

This study includes an assessment of the potential use of hydrodynamic separation and/or screening to remove phytoplankton and larger particulate matter from the water as a means to reduce nutrient and organic matter loading in the Klamath River. Field tests of hydrodynamic separation were conducted in 2011, 2012 and 2013. A draft technical report on these results was distributed to the IMIC in April 2013. PacifiCorp is in the process of reviewing comments and anticipates releasing a final report in July 2013. Continued work on this technology is proposed for 2013-2014 to assess performance objectives that would be necessary to achieve meaningful water quality improvements, which will then inform the development of costs for such a system.

Organic Matter Separation Test Unit at A-Canal Fish Screen

7.12.3 Evaluation of J.C. Boyle Reservoir Dissolved Oxygen Improvement

The purpose of this study is to conduct planning for, and testing of, technologies for improving dissolved oxygen (DO) conditions in J.C. Boyle reservoir. Information is being gathered on commercially available technologies for

Supersaturated Dissolved Oxygen (SDOX®) Test Unit

improving DO in the reservoir, including oxygenation, air injection, and mechanical mixing. Elements of this study also include DO testing and a pilot project of direct DO injection into J.C. Boyle reservoir.

During 2011, study activities included field assessment of a specific oxygenation method with potential application to J.C. Boyle reservoir – the Supersaturated Dissolved Oxygen (SDOX®) system. The SDOX® technology involves withdrawing a small stream of water from the body of water to be treated, bringing that stream up to a pressurized saturation tank where oxygen gas is pre-dissolved into the stream to achieve a supersaturated DO concentration. The stream of water is then re-injected back into the main water body, thereby increasing the DO concentration in the receiving water. A pilot demonstration, conducted in September 2011, showed a rise in DO levels within the reservoir.

A final report on the assessment of DO improvement technologies that may be applicable to J.C. Boyle was submitted to the IMIC in July 2013.

7.12.4 Testing of Intake Cover for Water Quality Control in Iron Gate Reservoir

This study involves the evaluation of a cover, or barrier, at the Iron Gate dam intake to improve the quality of water discharged from the powerhouse as an interim measure. The concept behind the intake barrier is to control the depth at which water is withdrawn from the reservoir into the intake, and thereby potentially enhance water quality downstream of Iron Gate dam by excluding or reducing the potential entrainment of biomass from blooms of cyanobacteria (blue-green algae) and potential associated algal toxins (i.e., microcystin).

In 2011, 2012, and 2013, PacifiCorp successfully tested the deployment of a barrier in front of the Iron Gate dam intake. The purpose of the 2011 test was to design and construct a 12-foot intake barrier and evaluate if the barrier could be safely and successfully deployed and retrieved from the intake without disrupting project operations. Subsequent work in August 2012 evaluated water quality effects below Iron Gate dam during cover deployment as well as changes in the withdrawal zone within the reservoir. In 2013, a more detailed bathymetric survey yielded a more refined understanding of the velocity field in this area, confirming previous observations (the bulk of the water approaches the intake tower from the north) and identifying potentially complex hydrodynamics in certain areas.

During the intake barrier deployment, these study tasks were completed:

- Velocity measurements were collected near the front of the intake tower to assess the depths at which water enters the intake tower without the cover and with the cover in place;

Iron Gate Intake Barrier Deployment

- Water quality probe measurements of water temperature, dissolved oxygen, pH downstream of Iron Gate Dam were collected to assess changes in Klamath River conditions with and without the cover in place. In addition, vertical water quality measurements of water temperature, dissolved oxygen, and pH were collected to characterize reservoir conditions during the experiment; and

- Nutrient and algal grab samples were collected in the river downstream to assess water quality impacts of lowering the cover.

Based on the initial results from the field work, it appears that the effectiveness of the cover employed for the study may be limited temporally as hydraulics around the intake readjust following cover deployment, although short-term improvements in water quality may occur. A draft technical report was submitted to the IMIC in April 2013 for review. PacifiCorp is currently addressing comments and revising study plans to evaluate potential future work in 2014. This work would include development of hydraulic/hydrodynamic modeling tools that may be used to assess potential geotextile curtain design and placement to reduce the potential entrainment of biomass from cyanobacteria blooms in the reservoir.

7.12.5 Pilot Study of Algal Conditions Management in Copco and Iron Gate Reservoirs

The purpose of this study is to conduct a localized application of an environmentally safe, hydrogen peroxide-based algaecide that is commonly employed throughout the country to reduce blue-green algae concentrations in drinking water reservoirs, lakes and water bodies used for public recreation. PacifiCorp has been evaluating various algaecides as a potential tool to locally improve water quality conditions in high public use areas of its reservoirs since 2008. Prior studies have used water from Copco reservoir in isolated containers to evaluate the effects of applying algaecide in order to determine whether such treatment may be effective at reducing algae concentrations without increasing microcystin concentrations as result of algal cell lysing. The study conducted in 2012 built upon previous studies in which the application of a hydrogen peroxide-based algaecide demonstrated effectiveness at reducing both algal cell density while also reducing microcystin concentrations.

While algaecide treatment is likely not economic or feasible for fully addressing algal concerns in Project reservoirs, this study is intended to assess whether algaecide may be one of many potential tools for managing reservoir water quality conditions in local portions of Project reservoirs (such as public access areas). Preliminary study results indicate that algaecide can be successful in reducing algal concentration while also reducing microcystin concentrations.

In 2013, PacifiCorp isolated a portion of Long Gulch Cove in Iron Gate reservoir with a geotextile curtain to evaluate different treatment depths so that the persistence of the effects of the treatment could be evaluated.

A draft report on the study results was submitted for the IMIC's review in April 2013, and PacifiCorp is currently evaluating comments on the draft report. A final report with a response to comments is expected in July 2013. Future study work in this area includes earlier application of the algaecide to assess its effectiveness in preventing a large cyanobacteria bloom.

Long Gulch Cove Algal Management Study Area

7.12.6 Klamath Tracking and Accounting Program

PacifiCorp is working in cooperation with the North Coast Regional Water Quality Control Board (NCRWQCB), Oregon Department of Environmental Quality (ODEQ), and United States Environmental Protection Agency (USEPA) Regions 9 and 10 and other interested parties in developing the Klamath Tracking and Accounting Program (KTAP) through which water quality improvements can be tracked and investments in water quality improvements can be identified to maximize the benefits of water quality improvement investments. A Protocol Handbook was completed in 2012 and PacifiCorp remains engaged in this process.

PacifiCorp participated in the April 2011 KTAP training and has contracted with The Freshwater Trust (TFT) on a nutrient reduction pilot project in the Klamath River basin. TFT will assist in evaluating the protocols developed by KTAP that will account for and track the water quality benefits derived from restoration projects. The goal of the pilot project is to reduce phosphorus loads through livestock exclusion and use the KTAP protocols and analytical tools to track and account for the resulting phosphorus reductions.

7.12.7 Planning and Design for a Demonstration Wetlands Facility Adjacent to the Klamath River

PacifiCorp proposes the concept of a demonstration wetlands facility (DWF) adjacent to the upper Klamath River to provide an important opportunity for interested stakeholders and researchers to investigate the site-specific requirements, effectiveness, feasibility, and costs of wetland technologies in the Upper Klamath basin. This information would be valuable for future planning, design, and ultimate implementation of wetland technologies to improve water quality in the Upper Klamath basin.

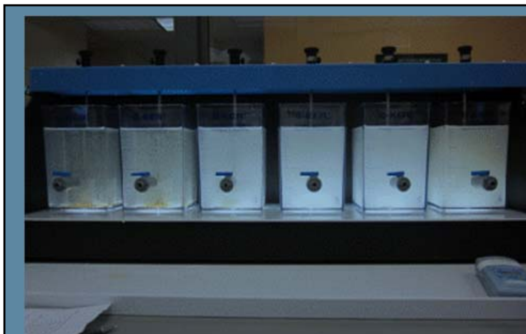
Based on IMIC recommendations, PacifiCorp formed a Technical Advisory Committee (TAC) comprised of local and regional water quality experts from state, federal, tribal and private organizations to move forward with further DWF planning during 2013-2014. Since October 2013, the TAC has been engaged in at least monthly conference calls to discuss various aspects and concepts of the DWF. A draft plan was submitted to the TAC in April 2014 and is still in the review process. A site visit to potential DWF sites is scheduled for July 2014 and a final study plan is expected in August 2014.

7.12.8 Pilot Study of Nutrient Reduction Methods in Klamath Basin Water Bodies

The purpose of this study is to conduct a proof-of-concept level investigation of potential approaches to reducing nutrient concentrations, notably phosphorus (P), as a means for overall water quality improvement in Upper Klamath Lake (UKL), Keno Reservoir, and the Klamath River and reservoirs (J.C. Boyle, Copco, and Iron Gate) downstream. This pilot study will assess the effects of treating isolated volumes of water from the area to reduce nutrient concentrations (and associated algae growth and biomass effects) through flocculation, binding, or sequestration experiments in discrete containers (i.e., bench scale testing).

A draft study plan outlining six different potential treatment agents was reviewed by the IMIC. Based on the IMIC and the TAC recommendations, a final study plan approach using four agents is being implemented in July 2014. The four agents selected for the laboratory-based bench testing, including:

- Lanthanum-modified bentonite clay (Phoslock™)
- Aluminum-modified zeolite (Z2G1 or Aqual P™)
- Polyaluminum hydroxychloride (PACl)
- Alum (aluminum sulfate buffered with sodium aluminate)



Jar testing setup for laboratory bench testing

7.13 Interim Measure 12: J.C. Boyle Bypass Reach and Spencer Creek Gaging

PacifiCorp shall install and operate stream gages at the J.C. Boyle Bypass Reach and at Spencer Creek. The J.C. Boyle Bypass Reach gaging station will be located below the dam and fish ladder and fish bypass outflow, but above the springs in order to record flow releases from J.C. Boyle Dam. The Spencer Creek gage will utilize an existing Oregon Water Resources Department gaging location. It is assumed that the required measurement accuracy will be provided using stage gaging at existing channel cross-sections with no need for constructed weirs. The installed stream gages shall provide for real-time reporting capability for half-hour interval readings of flow and gage height, accessible via an agreed-upon website, until such time as it is accessible on the USGS website. The Spencer Creek gage shall be installed in time to provide flow indication for Iron Gate Flow Variability (ICP Interim Measure 5). Both gages shall be installed and functional prior to September 1, 2010. Installation of the bypass gage, and measurement and maintenance shall conform to USGS standards. The Spencer Creek gage will be maintained according to USGS standards, as applicable.

PacifiCorp completed installation of the J.C. Boyle bypass reach gage in 2011 and the gage is functional and logging data. Gaging data for the J.C. Boyle bypass reach gage is available at:

http://www.pacificorp.com/es/hydro/hl/wr/kr.html

Gaging data for the Spencer Creek gage is available at the following website:

http://apps.wrd.state.or.us/apps/sw/hydro_near_real_time/display_hydro_graph.aspx?station_nbr=11510000

7.14 Interim Measure 13: Flow Releases and Ramp Rates

PacifiCorp will maintain current operations including instream flow releases of 100 cubic feet per second (cfs) from J.C. Boyle Dam to the J.C. Boyle bypass reach and a 9-inch per hour ramp rate below the J.C. Boyle powerhouse prior to transfer of the J.C. Boyle facility.

Provided that if anadromous fish have volitional passage to the J.C. Boyle bypass reach after removal or partial removal of the lower dams and before J.C. Boyle is transferred, PacifiCorp will operate J.C. Boyle as a run of river facility with a targeted ramp rate not to exceed 2 inches per hour, and flows will be provided in the J.C. Boyle bypass reach to provide for the appropriate habitat needs of the anadromous fish species. The operation will also avoid and minimize take of any listed species present. Daily flows through the J.C. Boyle powerhouse will be informed by reservoir inflow gages below Keno Dam and at Spencer Creek. Provided further that if anadromous fish have volitional passage upstream of Iron Gate Dam before the Copco Facilities are transferred, PacifiCorp will operate the remaining Copco Facility that is furthest downstream as a run of the river facility with a targeted ramp rate not to exceed 2 inches per hour and coordinate with NMFS and FWS to determine if any other flow measures are necessary to avoid or minimize take of any listed species present. In either event, flows in the respective bypass reaches will be based on species-specific habitat needs identified by the IMIC.

The Parties agree that if dam removal occurs in a staged manner, J.C. Boyle is intended to be the last dam decommissioned. If, however, the Secretarial Determination directs a different sequence for Decommissioning and Facilities Removal, then the Parties

shall Meet and Confer to identify adjustments necessary to implement the Secretarial Determination in a manner that is consistent with PacifiCorp's Economic Analysis.

PacifiCorp is maintaining flow releases and ramp rates consistent with the existing FERC license and the requirements of applicable biological opinions as contemplated by this interim measure.

7.15 Interim Measure 14: 3,000 cfs Power Generation

Upon approval by OWRD in accordance with Exhibit 1, PacifiCorp may divert a maximum of 3,000 cfs from the Klamath River at J.C. Boyle dam for purposes of power generation at the J.C. Boyle Facility prior to decommissioning of the facility. Such diversions shall not reduce the minimum flow releases from J.C. Boyle dam required of PacifiCorp under Interim Measure 13. The implementation of this interim measure shall not: reduce or adversely affect the rights or claims of the Klamath Tribes or the Bureau of Indian Affairs for instream flows; affect the operation of Link River dam or Keno Dam or any facility of the Klamath Reclamation Project; or otherwise adversely affect lake levels at Upper Klamath Lake, flows in Link River, or Keno reservoir elevations. Within 9 months of the Effective Date, PacifiCorp and the Committee shall develop a protocol for quantifying and managing any additional flows in the Klamath River made available through implementation of the KBRA and for coordinating with operation of the J.C. Boyle Facility the timing and manner of release of such KBRA flows to meet fish habitat needs.

Juvenile Coho Salmon

As contemplated by this interim measure and pursuant to the Water Rights Agreement between PacifiCorp and the State of Oregon contained in Exhibit 1 of the KHSA, the OWRD issued a limited license to PacifiCorp on April 20, 2010, authorizing diversions to the J.C. Boyle powerhouse of up to 3,000 cfs. This limited license was renewed on March 9, 2011, and again on May 24, 2012. During the August 18, 2010 meeting, the IMIC discussed the framework of a protocol to quantify and manage any additional flows in the Klamath River made available through implementation of the KBRA and to coordinate the release of those flows with the operation of the J.C. Boyle facility. The protocol was reviewed and approved by the IMIC at the November 16, 2010 meeting.

7.16 Interim Measure 15: Water Quality Monitoring

PacifiCorp shall fund long-term baseline water quality monitoring to support dam removal, nutrient removal, and permitting studies, and also will fund blue-green algae (BGA) and BGA toxin monitoring as necessary to protect public health. Funding of $500,000 shall be provided per year. The funding shall be made available beginning on April 1, 2010 and annually on April 1 until the time the dams are removed. Annual coordination and planning of the monitoring program with stakeholders will be performed through the Klamath Basin Water Quality Group or an entity or entities agreed upon by the Parties and in coordination with the appropriate water quality agencies. The Regional Board and ODEQ will take responsibility for ensuring that the planning documents will be completed by April 1 of each year. Monitoring will be performed by the Parties within their areas of regulatory compliance or Tribal responsibility or, alternatively, by an entity or entities

agreed upon by the Parties. Monitoring activities will be coordinated with appropriate water quality agencies and shall be conducted in an open and transparent manner, allowing for participation, as desired, among the Parties and water quality agencies.

Significant disputes that may arise between the Parties, or with the Regional Board, regarding the monitoring plan content or funding will be resolved by the Implementation Committee, acting on input and advice, as necessary, from the water quality agencies. Notwithstanding the forgoing, the Oregon Department of Environmental Quality and the California State Water Resources Control Board shall make final decisions regarding spending of up to $50,000 dedicated to BGA and BGA toxin monitoring as necessary to protect public health.

PacifiCorp is now in the sixth year (2014) of funding baseline water quality monitoring consistent with this interim measure, which was begun under the AIP. Annual planning, coordination and monitoring for Interim Measure 15 is done collaboratively with PacifiCorp, ODEQ, NCRWQCB, USEPA Region 9, the Karuk and Yurok Tribes, and Reclamation. The baseline monitoring program occurs over approximately 250 miles of river and reservoirs waters from Link dam near Klamath Falls to the Klamath River estuary near Klamath, CA throughout most of the year. Parameters measured include basic water quality (temperature, dissolved oxygen, pH, and conductivity) and a suite of nutrients.

The public health monitoring component is intended to provide timely information that can be used to inform public health agencies if cyanobacteria are present, generating toxins of concern; and to determine the need to post warning notices and issue advisories for the reservoirs and/or areas of the river. The public health monitoring is done on a more frequent basis (e.g., weekly) at public access points along Copco and Iron Gate reservoirs and the Klamath River. Water samples are rushed for analysis and results are immediately forwarded to public health entities. Bi-weekly public health memos that summarize all the public health data are provided by each monitoring entity to California's Klamath Basin Monitoring Program (KBMP) website (http://www.kbmp.net/blue-green-algae-tracker).

Water Quality Sampling in Iron Gate Reservoir

Interim Measure 15 water quality monitoring is coordinated to ensure appropriate quality assurance protocols and standard operating procedures, with transparency a key element of the program. Study plans, laboratory comparison memos, annual summary reports and data are available on the KBMP website (http://www.kbmp.net).

A special study by the Karuk and Yurok tribes was begun in 2011 and is continuing for characterizing the periphyton algal community in the Klamath River. The lack of periphyton community information has been identified as a data gap in the understanding of Klamath River water quality and the development of this data will be useful for assessing long-term changes that may occur with planned dam removal.

7.17 Interim Measure 16: Water Diversions

PacifiCorp shall seek to eliminate three screened diversions (the Lower Shovel Creek Diversion – 7.5 cfs, Claim # S015379; Upper Shovel Creek Diversion – 2.5 cfs, Claim # S015381; and Negro Creek Diversion – 5 cfs, Claim # S015380) from

Shovel and Negro Creeks and shall seek to modify its water rights as listed above to move the points of diversion from Shovel and Negro Creeks to the mainstem Klamath River. Should modification of the water rights be feasible, and then successful, PacifiCorp shall remove the screened diversions from Shovel and Negro creeks associated with PacifiCorp's water rights prior to the time that anadromous fish are likely to be present upstream of Copco reservoir following the breach of Iron Gate and Copco dams. To continue use of the modified water rights, PacifiCorp will install screened irrigation pump intakes, as necessary, in the Klamath River. The intent of this measure is to provide additional water to Shovel and Negro creeks while not significantly diminishing the water rights or the value of ranch property owned by PacifiCorp. Should costs for elimination of the screened diversions and installation of a pumping system to provide continued use of the water rights exceed $75,000 then the Parties will Meet and Confer to resolve the inconsistency.

Implementation of this measure to relocate irrigation diversions on tributaries above Copco Reservoir is not contemplated to occur until just prior to the reintroduction of anadromous fish as a result of potential dam removal.

7.18 Interim Measure 17: Fall Creek Flow Releases

Within 90 days of the Effective Date and during the Interim Period for the duration of its ownership while this Settlement is in effect, PacifiCorp shall provide a continuous flow release to the Fall Creek bypass reach targeted at 5 cfs. Flow releases shall be provided by stoplog adjustment at the diversion dam and shall not require new facility construction or the installation of monitoring equipment for automated flow adjustment or flow telemetry.

Additionally, if anadromous fish have passage to the Fall Creek following removal of the California dams, flows will be provided in the Fall Creek bypass reach to provide for the appropriate habitat needs of the anadromous fish species of any kind that are naturally and volitionally present in the Fall Creek bypass reach. Flows will be based on species specific habitat needs identified by the IMIC. The operation will also avoid and minimize take of any listed species present.

Pursuant to Interim Measure 17, PacifiCorp adjusted instream flow releases in the Fall Creek bypass reach from 0.5 cfs to 5 cfs on May 18, 2010. The additional instream flow release is being provided through an existing bypass culvert at the Fall Creek diversion dam. PacifiCorp's operations staff monitors this flow release during the course of their routine visits to the Fall Creek diversion dam to ensure that the instream flow is maintained.

7.19 Interim Measure 18: Hatchery Funding

Beginning in 2010, PacifiCorp shall fund 100 percent of Iron Gate Hatchery operations and maintenance necessary to fulfill annual mitigation objectives developed by the California Department of Fish and Wildlife in consultation with the National Marine Fisheries Service and consistent with existing FERC license requirements. PacifiCorp shall provide funding of up to $1.25 million dollars per year for operations and maintenance costs, subject to adjustment for inflation as set forth in Section 6.1.5 of the Settlement. These operations and maintenance costs shall include a program for 25 percent fractional marking of chinook at the Iron Gate Hatchery facilities as well as the current 100 percent marking program for coho and steelhead. Labor and materials costs associated with the 25 percent fractional marking program (fish marking, tags, tag recovery, processing, and data entry) shall be included within these

operations and maintenance costs. This operations and maintenance funding will continue until the removal of Iron Gate Dam.

PacifiCorp will provide one-time capital funding of $1.35 million for the 25 percent fractional marking program. This funding will include the purchase of necessary equipment (e.g., electrical upgrades, automatic fish marking trailer, tags and a wet lab modular building for processing fish heads). PacifiCorp will ensure the automatic fish marking trailer is available for use by April 2011. PacifiCorp is not responsible for funding the possible transition to a 100 percent Chinook marking program in the future.

New CDFW Wet Lab for Reading Adult Salmon Tags

PacifiCorp owns the Iron Gate Hatchery and the current Project license requires PacifiCorp to fund 80 percent of Iron Gate Hatchery operations and maintenance costs, with the remainder provided by CDFW. However, under this interim measure PacifiCorp has assumed funding 100 percent of these costs. Consistent with the interim measure, PacifiCorp purchased a fish marking system for the Iron Gate Hatchery to provide 25 percent constant fractional marking of Chinook salmon produced at the hatchery, which was begun in 2009. The marking trailer was first used in the spring of 2011. The increased marking percentage at Iron Gate hatchery is expected to provide better data on the contribution of the hatchery to basin salmon escapement, which should improve fisheries management. PacifiCorp worked closely with CDFW on the specification and purchase of a wet lab modular building to be used by CDFW for reading tag data on returning adult salmon. This building was completed in September 2012 and will improve acquisition of this important resource management information.

7.20 Interim Measure 19: Hatchery Production Continuity

Within 6 months of the Effective Date of the Settlement, PacifiCorp will begin a study to evaluate hatchery production options that do not rely on the current Iron Gate Hatchery water supply. The study will assess groundwater and surface water supply options, water reuse technologies or operational changes that could support hatchery production in the absence of Iron Gate Dam. The study may include examination of local well records and the feasibility of increasing the production potential at existing or new hatchery facilities in the basin.

Based on the study results, and within 6 months following an Affirmative Determination, PacifiCorp will propose a post-Iron Gate Dam Mitigation Hatchery Plan (Plan) to provide continued hatchery production for eight years after the removal of Iron Gate Dam. PacifiCorp's 8 year funding obligation assumes that dam removal will occur within one year of cessation of power generation at Iron Gate Dam. If dam removal occurs after one year of cessation of power generation at Iron Gate Dam, then the Parties will Meet and Confer to determine appropriate hatchery funding beyond the 8 years. PacifiCorp's Plan shall propose the most cost effective means of meeting hatchery mitigation objectives for eight years following removal of Iron Gate Dam. Upon approval of the Plan by the California Department of Fish and Game and the National Marine Fisheries Service, PacifiCorp will begin

implementation of the Plan. Plan implementation may include PacifiCorp contracting with the owners or administrators of other identified hatchery facilities and/or funding the planning, design, permitting, and construction of measures identified in the Plan as necessary to continue to meet mitigation production objectives. Five years after the start of Plan implementation, PacifiCorp, the California Department of Fish and Game and the National Marine Fisheries Service shall meet to review the progress of Plan implementation. The five year status review will also provide for consideration of any new information relevant to Plan implementation. Plan implementation shall ultimately result in production capacity sufficient to meet hatchery mitigation goals for the eight year period being in place and operational upon removal of Iron Gate Dam.

PacifiCorp has begun the study to evaluate hatchery production options that do not rely on the current Iron Gate Hatchery water supply. PacifiCorp engineering and environmental staff are researching available water supply options in the area and historic records on hatchery water supply options considered at the time Iron Gate Hatchery was constructed. PacifiCorp, in consultation with CDFG, has developed preliminary alternatives for continued hatchery operations that are being evaluated with further engineering and economic analysis to develop a feasibility study of potential hatchery alternatives that could be employed following the removal of Iron Gate dam.

7.21 Interim Measure 20: Hatchery Funding After Removal of Iron Gate Dam

After removal of Iron Gate Dam and for a period of eight years, PacifiCorp shall fund 100 percent of hatchery operations and maintenance costs necessary to fulfill annual mitigation objectives developed by the California Department of Fish and Game in consultation with the National Marine Fisheries Service. The hatchery mitigation goals will focus on Chinook production, with consideration for steelhead and coho, and may be adjusted downward from current mitigation requirements by the California Department of Fish and Game and National Marine Fisheries Service, in consultation with the other Klamath River fish managers, in response to monitoring trends.

State-of-the-Art Marking and Recording Equipment at Iron Gate Hatchery

No implementation actions have occurred for this interim measure given that this requirement begins only following removal of Iron Gate dam.

7.22 Interim Measure 21: BLM Land Management Provisions

Beginning in 2010 and continuing until transfer of the J.C. Boyle facility, PacifiCorp shall fund land management activities by the Bureau of Land Management as specified in this interim measure. BLM will provide PacifiCorp an annual Work Plan for the management measures described below for road maintenance, invasive weed management, cultural resource management, and recreation. The Work Plan will include the status of Work Plan tasks from the prior year, a description of the prioritized tasks for the upcoming year, and their estimated costs.

PacifiCorp or BLM will mutually establish the annual delivery date of the Work Plan taking into consideration fiscal and maintenance calendars and may request a meeting to coordinate the content of the plan. PacifiCorp will provide funding within 60 days of concurring with the Work Plan. Administrative services, environmental review or permitting efforts, if necessary, to implement actions under the funds shall not require additional PacifiCorp funding beyond the amounts specified below.

A. PacifiCorp shall provide up to $15,000 per year to BLM towards projects identified through the coordination process described above for the purpose of road maintenance in the Klamath Canyon. This funding will be used to annually maintain the access road from State Highway 66 to the J.C. Boyle Powerhouse and terminate at the BLM Spring Island Boat Launch. Remaining funds will be used to do non-recurring road maintenance work on roads within the Canyon as mutually agreed upon in writing by BLM and PacifiCorp.

B. PacifiCorp shall provide up to $10,000 per year to BLM for use by the Oregon Department of Agriculture (ODA) towards projects identified through the coordination process described above for the purpose of integrated weed management of invasive weed species along the road system and river corridor within the Klamath Canyon. Noxious weed control projects will be coordinated with Siskiyou County to ensure that weeds are controlled along the river corridor from the Oregon-California boundary to the top of Copco Reservoir.

C. PacifiCorp shall provide up to $10,000 per year to BLM towards projects identified through the coordination process described above for the management of the following 5 BLM cultural sites which are within, or partially within, the T1 terrace of the J.C. Boyle full flow reach: 35KL21/786, 35KL22, 35KL24, 35KL558, and 35KL577. Management of additional sites with these funds can occur with mutual written agreement between PacifiCorp and BLM.

D. PacifiCorp shall provide up to, but no more than, $130,000 in funding for the development and implementation of a Road Management Plan to be implemented during the Interim Period. The Road Management Plan shall be developed by BLM and PacifiCorp and will determine priorities for operation and maintenance, including remediation or restoration of redundant or unnecessary facilities, of the shared BLM/PacifiCorp road system within the Klamath River Canyon from J.C. Boyle Dam to the slack water of Copco Reservoir.

For 2014, the BLM will continue to use funding under this interim measure for cultural resources, road maintenance, and invasive weed management. Recent actions implemented under this interim measure include the following:

- Cultural Resources: Perform detailed monitoring and re-recording of cultural sites including updating baseline data for each of the sites, including site location and sketch maps, site conditions, and the acquisition of new GIS data.
- Road Maintenance: In 2013, approximately 4.78 miles of Topsy Road road from Highway 66 to Topsy Campground were graded and additional road surfacing will be completed between J.C. Boyle dam and Highway 66.
- Invasive Weed Management: the BLM has outlined a ten year plan for addressing invasive weed management in the defined corridor. The product of this work will be information that will allow land managers to determine the best strategy for future integrated weed management activities. Work now underway will include treatments for invasive weeds within 4,390 acres of the Klamath River Canyon in both Oregon and California.

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