APPENDICES

Klamath Facilities Removal Public Draft Environmental Impact Statement/ Environmental Impact Report

State Clearinghouse
2010062060

U.S. Department of the Interior

CA Department of Fish & Game

September 2011

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Abbreviations and Acronyms

AF	Acre-feet
AIP	Agreement in principle
AWS	Auxiliary water supply
CDFG	California Department of Fish and Game
cfs	Cubic feet per second
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
DOI	United States Department of the Interior
DRE	Dam Removal Entity
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FEMP	Fishway Evaluation and Modification Plan
FERC	Federal Energy Regulatory Commission
FSBC	Floating surface bypass collector
ft	Feet
KBRA	Klamath Basin Restoration Agreement
KHSA	Klamath Hydroelectric Settlement Agreement
mi	Miles
MW	Megawatts
NCRWCQB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NOAA Fisheries Service	National Oceanic and Atmospheric Administration Fisheries Service
NWR	National Wildlife Refuge
ODEQ	Oregon Department of Environmental Quality
OWRD	Oregon Water Resources Department
PCBs	Polychlorinated biphenyls
Reclamation	Bureau of Reclamation
RM	River mile
Secretary	Secretary of the Interior
TMDLs	Total maximum daily loads
USFWS	United States Fish and Wildlife Service
WURP	Water Use Retirement Program
yd^3	Cubic yards

Chapter 1 Introduction

1.1 Background

The Klamath Basin is in southern Oregon and northern California. Klamath River flow is controlled by six dams: Link River, Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams (Figure 1-1). The dams, with the exception of Keno Dam, are hydroelectric generating facilities, and make up the Klamath Hydroelectric Project, which is owned and operated by PacifiCorp. The Klamath Hydroelectric Project is regulated by the Federal Energy Regulatory Commission (FERC) as project No. 2082. On February 24, 2004, PacifiCorp filed an application with FERC for a new operating license for the Klamath Hydroelectric Project. The original FERC license pre-dated environmental laws, and most of the Klamath Hydroelectric Project does not include conditions or prescriptions for fish passage upstream of or around the dams; only J.C. Boyle Dam has fish passage facilities. The original license expired on March 1, 2006. Since that time, per FERC regulations, the Klamath Hydroelectric Project has been operating under an annual license with the same conditions as the original license.

This report describes the alternatives to removing four PacifiCorp Dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate), as described in the Klamath Hydroelectric Settlement Agreement (KHSA). This introduction provides a summary of background information for the Alternatives Report. For more information on the Klamath Basin, the "Layperson's Guide" is available at http://www.klamathrestoration.gov.

1.1.1 History

Upper Klamath Lake and other waterways in the upper watershed provide habitat for the Lost River and shortnose suckers that are listed as endangered under the Federal Endangered Species Act (ESA) and California Endangered Species Act (CESA). Releases from Iron Gate Dam also affect ESA- and CESA-listed coho salmon, Chinook salmon, trout, and other fishes in the Lower Klamath Basin. Without fish passage structures, the hydroelectric facilities block salmon, steelhead, Pacific lamprey, and other species from accessing 350 miles of potential habitat.

In the Klamath Basin, conflicts over water and other natural resources among conservationists, tribes, farmers, fishermen, and state and federal agencies have existed for decades. In particular, several developments affecting the Klamath Basin conflicts have occurred in recent years. These developments include:

- In 2001, water deliveries to irrigation contractors to the Bureau of Reclamation's (Reclamation's) Klamath Project were substantially reduced.
- In 2002, returning adult salmon suffered a major die-off.

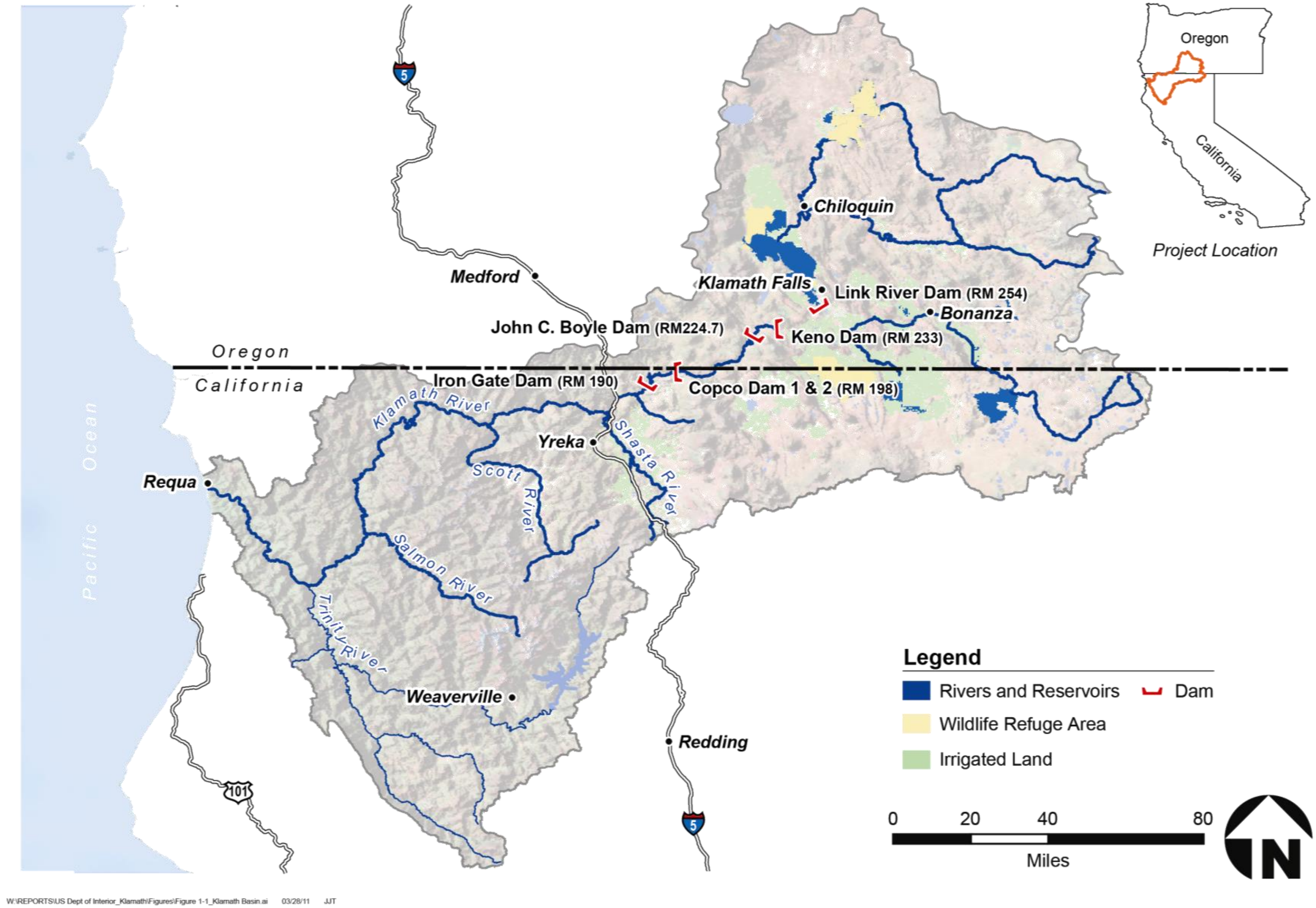

Figure 1-1. Basin Map

- In 2006, the commercial salmon fishing season was closed along 700 miles of the West Coast to protect weak Klamath River stocks.
- In 2010, due to drought conditions, Reclamation's Klamath Project has a reduction in water deliveries resulting in short-term idling of farmland and increased groundwater pumping.
- In 2010, the c'waam (Lost River suckers) fishery for the Klamath Tribes was closed for the 24th year, limiting the Tribes to only a ceremonial harvest.

Since 2003, the United States has spent over $500 million in the Klamath Basin for management actions associated with irrigation, fisheries, and the Klamath Basin National Wildlife Refuge System and resource enhancements.

Fish considerations were a major issue during the FERC relicensing process, which is now in abeyance. The U.S. Department of Commerce and the U.S. Department of the Interior (DOI) submitted fishway prescriptions in 2006 and modified prescriptions in 2007. FERC published a Final Environmental Impact Statement (Final EIS) to comply with the National Environmental Policy Act (NEPA) in November 2007. FERC has not issued a new license for the Project.

As a result of protracted litigation and the Klamath Basin issues surrounding the use of water to support agricultural, tribal, environmental, and commercial fishing needs based upon limited supplies, the United States, the States of California and Oregon, the Klamath, Karuk, and Yurok Tribes, Klamath Project Water Users, and other Klamath Basin stakeholders entered into negotiations to explore possible approaches to resolution of these issues other than through the FERC relicensing process. In November 2008, the four principal parties, the United States, the states of Oregon and California, and PacifiCorp signed an AIP. The AIP contemplated the possibility that, rather than pursue further the FERC relicensing process, the Secretary of the Interior (Secretary) should complete certain studies and make a determination as to whether certain of the facilities (J.C. Boyle, Copco 1, Copco 2 and Iron Gate Dams and appurtenant works, herein referred to as the Four Facilities) in the Klamath Hydroelectric Project should be removed, either all or part of each, to achieve at a minimum a free-flowing condition and volitional fish passage (KHSA 1.4), and by whom, to advance the restoration of salmonid fisheries in the Klamath Basin. The parties recognized that federal legislation would be needed to authorize the Secretary to make such a determination regarding privately owned facilities, and to provide indemnification for PacifiCorp for any liabilities that may accrue to PacifiCorp as a result of facilities removal. As originally contemplated in the AIP, this determination by the Secretary would be whether "the potential benefits for fisheries, water and other resources for removing the facilities would outweigh the potential costs, risks, liabilities or other adverse consequences of such removal." (AIP, at III, p. 5)

1.1.2 Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement

As a continuation of the process that led to the AIP, the principal parties negotiated the final agreements with a larger group of stakeholders that included representatives from tribes, the fishing community, irrigators, and environmental groups. On February 18, 2010, the Secretary, along with the Governors of Oregon and California, more than 30 other parties and the CEO of PacifiCorp, signed the KHSA. At the same time, those same parties, except for the federal parties and PacifiCorp, signed an accompanying agreement, the KBRA. The KBRA was designed to address disagreements over quantities of water; specifically, tensions regarding in-stream flows needed for endangered sucker and salmon species in Upper Klamath Lake and the Klamath River, and water for use in the Reclamation's Klamath Project for irrigation purposes. If fully implemented, the KBRA is intended to result in effective and durable solutions that accomplish the following: (1) restore and sustain natural fish production and provide for full participation in ocean and river harvest of fish species throughout the Klamath Basin; (2) establish reliable water and power supplies that sustain agricultural uses, communities, and National Wildlife Refuges (NWRs); and (3) contribute to the public welfare and the sustainability of all Klamath Basin communities. (KBRA Section 1.3.)

Section 3.3 of the KHSA sets out the terms for the Secretarial Determination and the required conditions that must be met before the Secretary can make a determination regarding removal of the Four Facilities. The KHSA contemplates the Secretary determining whether the four dams should be removed, in whole or in part to achieve at a minimum a free-flowing condition and volitional fish passage (KHSA Section 1.4.). The KHSA also contemplates the Secretary determining who should remove the dams if an affirmative determination is made:

> By March 31, 2012, the Secretary shall use best efforts to (i) determine whether the costs of Facilities Removal as estimated in the Detailed Plan,[1] including the cost of insurance, performance bond, or similar measures, will not exceed the State Cost Cap,[2] and (ii) otherwise complete his determination whether to proceed with Facilities Removal as described in Section 3.3.1, provided that any such determination shall not be made until the following conditions have been satisfied:
>
> A. Federal legislation, which in the judgment of the Secretary is materially consistent with Appendix E, has been enacted;
>
> B. The Secretary and PacifiCorp have authorized funding for Facilities Removal as set forth in Section 4 of this Settlement;
>
> C. The States of Oregon and California have authorized funding for Facilities Removal as set forth in Section 4 of this Settlement;
>
> D. The Parties have developed a plan to address the excess costs, consistent with Section 4.10 of the Settlement, if the estimate of costs prepared as part of the Detailed Plan (including the cost of insurance, performance bond, or similar measures) shows that there is a reasonable likelihood such costs are likely to exceed the State Cost Cap; and

[1] The Secretary's determination and concurrence from the states will be based, in part, on a "Detailed Plan for Facilities Removal" (Detailed Plan) that describes the following: physical methods to remove the dams and achieve a free-flowing condition; plans for removal of sediment and debris; restoration plans; mitigation measures; plans for obtaining permits; estimated costs; measures to reduce the potential to overrun costs; and identification of a dam removal entity (DRE) to oversee removal efforts.

[2] Defined as the collective maximum monetary contribution from the states of California and Oregon, described in Section 4.1.3 of the KHSA.

E. The Secretary has identified a dam removal entity (DRE)-designate, and, if the DRE-designate is a non-federal entity: (i) the Secretary has found that the DRE-designate is qualified; (ii) the States have concurred in such finding; and (iii) the DRE-designate has committed, if so designated, to perform Facilities Removal within the State Cost Cap. (KHSA Section 3.3.4)

An Affirmative Determination in this regard would mean, facilities removal should proceed for all or part of each of the Four Facilities. As noted above, in the event of an Affirmative Determination, the Secretary must also designate who should carry out such removal, whether a federal or private DRE. A Negative Determination means, "a determination by the Secretary under Section 3 of this Settlement that Facilities Removal should not proceed." Under the KHSA, the standard the Secretary shall use to determine whether the dams should be removed is (1) whether it will advance the restoration of the salmonid fishery and (2) whether it is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes. The studies contemplated in the KHSA are intended to inform the Secretarial Determination in light of these standards. If the Secretary makes an Affirmative Determination, the governors of the states of California and Oregon must issue independent concurrences with both the decision on dam removal and selection of a DRE. (KHSA Section 3.3.5.)

The KHSA assumes that environmental analysis supporting the Secretarial Determination will be prepared pursuant to NEPA. The analysis of the environmental consequences of the Proposed Action and its alternatives will be based on information that emerged from the FERC NEPA process, and will be informed, to the extent possible and appropriate, by the results of the specific studies called for in the KHSA, including the information under development for the Detailed Plan (KHSA, 3.3.2).

1.1.3 Facilities Description

The KHSA addresses removal of the Four Facilities: J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams. Table 1-1 contains information about each facility that was used for alternative development.

Table 1-1. Klamath Hydroelectric Dams

Dam	Year Operational	Height (ft)	Length (ft)	Storage Capacity (AF)	Generation Capacity (MW)	Type of Fish Ladder	Dam Type
J.C. Boyle	1958	68	692	2,629 AF at RWS elevation 3793.5	98	Pool and weir ladder	Earthfill and Concrete
Copco 1	1918	135	410	40,000 AF at RWS elevation 2,607.5	20	None	Concrete Gravity Arch
Copco 2	1925	33	335	70 AF at RWS elevation 2,483	27	None	Concrete
Iron Gate	1962	189	740	53,800 AF at RWS elevation 2,328	18	Partial ladder to hatchery	Earthfill

Key:
ft: feet
AF: acre-feet
MW: megawatts
RWS: river water surface
Source: FERC 2007; DOI 2011

1.2 Purpose of the Report

In order for the Proposed Action to move forward, the Secretary needs to make a determination that facilities removal should occur, and the governors of California and Oregon need to concur. The DOI and the State of California are completing a joint Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) to comply with NEPA and the California Environmental Quality Act (CEQA). Compliance with NEPA and CEQA will help provide information to decision-makers regarding the potential effects of dam removal.

This Alternatives Report documents the process of identifying alternatives for the EIS/EIR and applying considerations to evaluate them. This process resulted in a full range of reasonable alternatives for detailed evaluation in the Klamath Facilities Removal EIS/EIR. The purpose of this report is to document how alternatives were identified, screened, and selected to carry forward for more detailed analysis in the EIS/EIR. The DOI and California, in conjunction with the Cooperating, Responsible, and Trustee Agencies, are using this structured planning process to ensure that a full range of alternatives is evaluated in compliance with NEPA and CEQA.

Chapter 2
Alternatives Development and Screening Process

Both NEPA and CEQA require EISs and EIRs, respectively, to identify a reasonable range of alternatives. The Klamath Facilities Removal EIS/EIR Lead Agencies (DOI and the California Department of Fish and Game [CDFG]) developed a structured process to identify and screen alternatives. Through internal and public scoping, the Lead Agencies identified a wide range of alternatives representing diverse viewpoints and needs. Figure 2-1 illustrates the process.

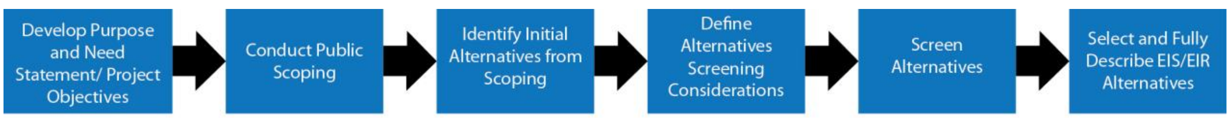

Figure 2-1. Alternatives Development and Screening Process

2.1 NEPA Purpose of and Need for Action/CEQA Objectives

The purpose and need statement (under NEPA) and objectives (under CEQA) describe the underlying need for and purpose of a proposed project. This statement is a critical part of the environmental review process because it helps to set the overall direction of an EIS/EIR, identify the range of reasonable alternatives, and focus the scope of analysis. The NEPA and CEQA Lead Agencies developed the following purpose and need/project objectives statement. This statement was published in the Notice of Intent to Prepare an EIS in the Federal Register and the Notice of Preparation of an EIR.

The NEPA purpose and need and each of the six primary CEQA objectives must be met to achieve the program’s purpose. Important physical, ecological, and socioeconomic linkages exist between the objectives and possible solutions. Accordingly, a solution to one objective cannot be pursued without addressing problems in the other resource categories. To practically achieve the purpose of the project and program, the solutions will need to concurrently and comprehensively address problems of the Klamath Basin.

2.1.1 Purpose and Need

The stated Purpose and Need statement below has changed since the publication of the Notice of Preparation in order to provide further clarification. These changes are not substantive and do not change any alternatives.

The Proposed Action is to remove the four lower PacifiCorp dams on the Klamath River. The need for the Proposed Action is to advance restoration of the salmonid fisheries in the Klamath Basin consistent with the KHSA and the connected KBRA. The purpose is to achieve a free flowing river condition and full volitional fish passage as well as other goals expressed in the KHSA and KBRA. By the terms of the KHSA, the Secretary will determine whether the Proposed Action is appropriate and should proceed. In making this determination, the Secretary will consider whether removal of the Four Facilities will advance the restoration of the salmonid fisheries of the Klamath Basin, and is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes.

2.1.2 Project Objectives

As required by CEQA, a lead agency must identify the objectives sought by the proposed project. For this project, CDFG as lead agency has identified the following objectives:

1. Advance restoration of the salmonid fisheries in the Klamath Basin.
2. Restore and sustain natural production of fish species throughout the Klamath Basin in part by restoring access to habitat currently upstream of impassable dams.
3. Provide for full participation in harvest opportunities for sport, commercial, and tribal fisheries.
4. Establish reliable water and power supplies, which sustain agricultural uses and communities and NWRs.
5. Improve long-term water quality conditions consistent with designated beneficial uses.
6. Contribute to the public welfare and the sustainability of Klamath Basin communities.

2.2 Alternative Identification

The public provided comments on the scope of the EIS/EIR during the public scoping period. Some of these comments included suggestions for alternatives to the Proposed Action. The Lead Agencies then used the purpose and need statement /project objectives to refine and clarify varying perspectives associated with the suggestions. The resulting preliminary list included more than 18 alternatives. Of these preliminary alternatives, some were determined to have limited functionality as a full alternative, as they focused on techniques for improving natural resource conditions and are already a part of the KBRA. The final result of the alternative identification process was 18 initial alternatives (Table 2-1). Section 3 describes these alternatives.

Table 2-1. Initial Alternatives

Alternative Number	Alternative Name	Description
Alternative 1	No Action/No Project	Implement none of the action alternatives; Klamath Hydroelectric Project would continue current operations.
Alternative 2	Full Facilities Removal of Four Dams (Proposed Action)	Remove four dams and related facilities.
Alternative 3	Partial Facilities Removal of Four Dams	Remove main areas of four dams to allow a free-flowing river; related facilities and/or abutments may remain.
Alternative 4	Fish Passage at Four Dams	Construct fish passage facilities to provide upstream and downstream passage at four dams.
Alternative 5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate	Remove Copco 1 and Iron Gate Dams, construct fish passage at J.C. Boyle and Copco 2 Dams.
Alternative 6	Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate	Remove Copco 1, Copco 2, and Iron Gate Dams, construct upgraded fish passage at J.C. Boyle Dam.
Alternative 7	Sequenced Removal of Four Dams	Remove four dams and related facilities over a period of three to five years.
Alternative 8	Full Facilities Removal of Four Dams without KBRA	Remove four dams and related facilities but do not implement restoration and other actions in the KBRA.
Alternative 9	Trap and Haul Fish	Capture fish at Iron Gate Dam and transport them upstream of J.C. Boyle Dam.
Alternative 10	Fish Bypass: Bogus Creek Bypass	Create a fish bypass using Bogus Creek, Cold Creek, Little Deer Creek and a constructed canal to connect to Copco 1 Reservoir.
Alternative 11	Fish Bypass: Alternative Tunnel Route	Create a fish bypass using Bogus Creek and a 5-mile tunnel to connect to Copco 1 Reservoir.
Alternative 12	Notching Four Dams	Notch four dams to create a free-flowing river.
Alternative 13	Federal Takeover of Project	Use the authority of the Federal Power Act for government to take over dams and initiate removal.
Alternative 14	Full Removal of Five Dams	Remove Keno Dam in addition to the four downstream dams.
Alternative 15	Full Removal of Six Dams	Remove Keno and Link River Dams in addition to the four downstream dams.
Alternative 16	Dredge Upper Klamath Lake	Remove sediments in Upper Klamath Lake to remove phosphorus and increase storage capacity.
Alternative 17	Predator Control	Control seal, sea lion, and cormorant populations that are salmonid predators.
Alternative 18	Partition Upper Klamath Lake	Create an “inner lake” that will have lower residence time and improved water quality.

2.3 Screening Consideration Definition

The Lead Agencies developed and applied a set of screening considerations to create a screening process that was fair and unbiased. The screening considerations were based on NEPA and CEQA guidance:

- NEPA requires that agencies shall "rigorously explore and objectively evaluate all the reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated" (40 CFR Part 1502.14(a)). The DOI NEPA procedures (43 CFR Part 46.420(b)) define reasonable alternatives as "alternatives that are technically and economically practical or feasible and meet the purpose and need of the proposed action."
- CEQA Guidelines section §15126.6 (a) states, "An EIR shall describe a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project." An EIR need not consider every conceivable alternative to a project or alternatives that are infeasible. (CEQA Guidelines, §15126.6 (a).) State CEQA Guidelines section 15364 defines feasible as "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors."

Both NEPA and CEQA include provisions that alternatives meet (or meet most of) the purpose and need/project objectives, and be potentially feasible. Under CEQA, alternatives do not need to meet all of the project objectives; alternatives should be included if they can meet most of the objectives and avoid or substantially lessen significant environmental impacts of the project. The NEPA and CEQA guidance led to the creation of the following screening considerations that are based on the NEPA purpose and need and CEQA objectives in Section 2.1.

Screening Considerations:

- Ability to meet the purpose and need/project objectives:
  - Would the alternative be consistent with the KHSA and KBRA?
  - Would the alternative result in a free-flowing condition on the Klamath River?
  - Would the alternative provide full volitional passage of fish? (Would fish voluntarily pass the facilities?)
  - Would the alternative advance restoration of the salmonid fisheries in the Klamath Basin?
  - Would the alternative provide for full participation in harvest opportunities for sport, commercial and tribal fisheries?
  - Would the alternative establish reliable water supplies that sustain agricultural uses and communities and NWRs?

  - Would the alternative establish reliable power supplies at affordable costs for communities?
  - Would the alternative improve long term water quality conditions consistent with both Oregon and California designated beneficial uses?
  - Would the alternative contribute to the public welfare and the sustainability of Klamath Basin communities?
- Technical feasibility
  - Would the alternative be technically feasible?

Several of the screening considerations above could not be used to narrow the list of alternatives. The purpose and need/project objectives include the overall goals for the agreements, but to apply some of the goals as screening criteria, more information is needed to describe and evaluate how well alternatives would meet these goals if implemented.

- Would the alternative provide for full participation in harvest opportunities? The answer to this question requires more significant analysis of effects of the alternatives on fish populations over time, which will occur during development of the EIS/EIR.
- Would the alternative contribute to the public welfare and the sustainability of Klamath Basin communities? Fully determining the potential effects of the alternatives requires analysis that will be described in the EIS/EIR.

Because these two questions require additional analysis, they were not included as considerations in the alternative screening process.

2.4 Alternative Screening and Selection

Disagreements regarding the use and management of the Klamath Basin have increasingly taken the form of protracted litigation and legislative battles. These disagreements have not yielded solutions to the water-related conflicts surrounding the Basin. The KHSA and KBRA were designed to reduce these conflicts and provide a solution that competing interests could support. Because both of the KHSA and KBRA are essential to the success of the Program, the alternative screening effort focuses on identifying alternatives that would both restore ecological health and improve water management for beneficial uses of the Klamath Basin system. Each alternative (other than the No Action Alternative) considered in this document would achieve these purposes.

The Lead Agencies screened the alternatives by applying the screening considerations based on available information and best professional judgment. The alternatives that will move forward for more detailed analysis in the EIS/EIR are those that best meet the NEPA purpose and need and CEQA objectives, minimize negative effects, are feasible, and represent a range of reasonable alternatives. Section 4 describes this screening process and its results in more detail.

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Chapter 3 Alternatives Overview

This section provides a brief overview of the alternatives considered during the development and screening process. Section 5 includes additional technical information on the alternatives that will move forward for more detailed analysis in the EIS/EIR.

The EIS/EIR will analyze the Proposed Action and alternatives. The KBRA and its component elements will be included in the EIS/EIR as connected actions. If a Negative Determination is made and the terms of the KHSA are not satisfied, then the KBRA and its component elements would not be implemented. Section 3.2.2 describes the KBRA.

3.1 Alternative 1 – No Action/No Project Alternative

NEPA requires an EIS to "include the alternative of no action" (40 CFR Part 1502.14(d)). CEQA requires an EIR to include a No Project Alternative. CEQA Guidelines Section 15126.6(e)(2) states that "the "no project" analysis shall discuss the existing conditions at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services." NEPA's No Action Alternative and CEQA's No Project Alternative describe the same conditions, and this alternative is referred to as the No Action/No Project Alternative.

The No Action/No Project Alternative represents the state of the environment without the Proposed Action or any of the alternatives. In this instance, the No Action/No Project Alternative would be no change from current management conditions, other than as noted below, with the dams remaining in place. The No Action/No Project Alternative would only include the portions of the KBRA that are ongoing resource management activities. These resource management actions would receive additional funding and could be expanded or accelerated through the KBRA; however, they were started or under consideration before the KBRA was developed and would move forward even without the KBRA. The No Action/No Project Alternative includes the assumption that the hydroelectric project would continue to operate under annual licenses issued by FERC to PacifiCorp.

Under the No Action/No Project Alternative, the Klamath Hydroelectric Project Interim Measures outlined in the KHSA would cease, except turbine venting. PacifiCorp would need to obtain a long-term operating license from FERC to replace the existing annual license. PacifiCorp would resume relicensing proceedings with FERC to obtain the required long-term operating license.

For the purposes of this analysis, the No Action/No Project Alternative would continue current operations with the dams remaining in place and PacifiCorp operating under the current annual license. The existing license has no requirements for additional fish passage or implementation of the prescriptions that are currently before FERC in the relicensing process. PacifiCorp would continue to operate the Iron Gate Hatchery under its current operations.

The USFWS issued a biological opinion to Reclamation on the operation and maintenance of Reclamation's Klamath Project (USFWS 2008). This biological opinion outlines measures to improve the habitat for the Lost River sucker and shortnose sucker affected by Reclamation's Klamath Project operations. Among other measures to protect the suckers, the biological opinion requires that specific surface elevations of Upper Klamath Lake be maintained to meet certain criteria.

NOAA Fisheries Service also issued a biological opinion to Reclamation requiring releases from Reclamation's Klamath Project to produce specified rates of flow for the Klamath River downstream of Iron Gate Dam, based on the habitat needs of coho salmon (NOAA Fisheries Service 2010). Target flow rates in the Klamath River downstream of Iron Gate Dam vary by month, and are dependent in part on the amount of water entering Upper Klamath Lake.

PacifiCorp would continue to coordinate operations with Reclamation and operate the Klamath Hydroelectric Project in compliance with existing NOAA Fisheries Service and USFWS biological opinions issued for Reclamation's Klamath Project. Under the No Action/No Project Alternative, the Four Facilities would continue to be subject to requirements in PacifiCorp's current annual FERC permit:

- Operating the peaking facility at J.C. Boyle such that the river does not rise or fall more quickly than 9 inches per hour and that minimum flows immediately downstream of the dam are maintained at 100 cubic feet per second (cfs).
- Maintaining minimum flows downstream of Iron Gate Dam.
- Limiting the change in the rate of the release of water from Iron Gate Dam to no more than 250 cfs per hour or a three-inch change in river stage. (FERC 2007)

PacifiCorp also currently coordinates with Reclamation to meet ramp rates in the NOAA Fisheries Service biological opinion on Reclamation's Klamath Project:

- When flows at Iron Gate Dam are 3000 cfs or above, Iron Gate Dam ramp down rates will follow the rate of decline to inflows to Upper Klamath Lake combined with accretions between Keno Dam and Iron Gate Dam.
- When flows at Iron Gate Dam are between 1,750 cfs and 3,000 cfs, Iron Gate Dam ramp down rates will be 300 cfs or less per 24 hour period and no more than 125 cfs per 4 hour period.
- When flows at Iron Gate Dam are 1,750 cfs or less, Iron Gate ramp down rates will be 150 cfs or less per 24 hour period and no more than 50 cfs per two hour period. (NOAA Fisheries Service 2010)

The No Action/No Project Alternative would include other regulatory conditions that would affect conditions in the Klamath Basin. To improve water quality, the Oregon Department of Environmental Quality (ODEQ) and California North Coast Regional Water Quality Control Board (NCRWQCB) cooperated to develop total maximum daily loads (TMDLs) for nine impaired water bodies within the basin. TMDLs are pollution control plans that identify the pollutant load reductions that are necessary from point and nonpoint sources to meet water quality standards. The California and Oregon Klamath River TMDLs focus on reducing high water temperatures, increasing dissolved oxygen levels, and reducing nutrient concentrations in the mainstem Klamath River (NCRWQCB 2010a, ODEQ 2010). Major tributaries in the lower Klamath Basin, such as the Scott, Shasta, and Trinity Rivers, are not included in the technical analyses (i.e., modeling efforts) for the California Klamath TMDLs, but the entire Klamath Basin is included in the associated Implementation Plan (NCRWQCB 2010b). The Implementation Plan focuses on four different areas of the Klamath Basin, two of which are relevant to the project:

- Stateline – the area surrounding the Oregon/ California Stateline. This area presents some management issues, as water quality in the Klamath River does not meet California standards when the river enters the state from Oregon. Nutrient loading from Oregon is believed to be primarily responsible for nuisance blue-green algae growth and associated water quality impairments in Copco 1 and Iron Gate Reservoirs as well as aquatic plant growth in the river. ODEQ has developed TMDLs for the upper Klamath and Lost rivers to meet both Oregon and California water quality standards and they were approved by the United States Environmental Protection Agency approval in December 2010 (ODEQ 2010). Parties responsible for TMDL implementation are listed in the staff report for the Klamath TMDLs and include ODEQ, Oregon Department of Agriculture, the U.S. Environmental Protection Agency Regions 9 and 10, the NCRWQCB, and both point and nonpoint sources in Oregon and the Lost River Basin in California (NCRWQCB 2010a).
- Klamath Hydroelectric Project and Iron Gate Hatchery – The Implementation Plan addresses the effects of the facilities in California, which are the Copco 1, Copco 2, and Iron Gate facilities. The TMDLs assign three allocations to the Klamath Hydroelectric Project in California: water temperature, dissolved oxygen, and nutrients (total phosphorus and total nitrogen). To achieve compliance with the TMDLs, multiple targets are also assigned, including nutrients, organic matter, and algae-based targets (chlorophyll-a, *Microcystis aeruginosa* cell density, the algal toxin microcystin). Responsible parties listed in the staff report for the Klamath TMDLs at this location are the NCRWQCB, the State Water Resources Control Board, and PacifiCorp. Once they are adopted, the TMDLs will become part of the Implementation Plan and thus part of the regulatory environment. They are therefore included in the No Action/No Project Alternative. If the Secretary makes a Negative Determination, PacifiCorp must submit a TMDL implementation plan that complies with the FERC relicensing and water quality certification process, and PacifiCorp will be required to implement measures that meet and/or offset TMDL allocations and targets as prescribed in the Implementation Plan (NCRWQCB 2010b).

TMDLs for eight of the nine impaired subbasins in the Klamath Basin have been adopted and are currently in the implementation phase (TMDLs for the California mainstem Klamath River were adopted on December 28, 2010). The Upper Klamath and Lost River TMDLs will be implemented during the Klamath Facilities Removal EIS/EIR period of analysis. These TMDLs are expected to result in improvements to water quality conditions, but the improvements cannot be quantified because of uncertainties regarding the timing and magnitude of mitigation projects necessary to achieve water quality standards.

3.2 Alternative 2 – Full Facilities Removal of Four Dams (Proposed Action)

Implementation of this alternative, the Proposed Action, would result in the removal of the Four Facilities and their appurtenant structures as described in the KHSA. The alternative would include the complete removal of power generation facilities, bypass canals, pipelines, and dam foundations (see Figure 3-1) during a 12-month period. Reservoir drawdown may begin earlier in 2019 to allow preparatory activities; dam removal would be targeted to be complete by December 31, 2020. The Proposed Action would also include riverbank stabilization and replanting within the former reservoir basins after complete drawdown.

Full removal of the Four Facilities in a single year would require specialized construction machinery and equipment and personnel. Work crews would be housed in nearby towns, campgrounds, and on-site housing (where available), and staging of equipment would need to occur in the months leading up to initiation of the removal. The project would require a build-up of equipment and personnel prior to reservoir drawdown and a closing down period after the removal is complete. These activities would take place over a period of months before and after the actual 12-month dam deconstruction period.

Deconstruction would require heavy equipment such as excavators, bulldozers, dump trucks, cranes, and support equipment. Water levels would be drawn down by notching the top of the dam or using low level outlets.

J.C. Boyle, Copco 1, and Iron Gate Dams have a large quantity of sediment deposited within their reservoirs. The volume of sediment within Copco 2 Reservoir is negligible because of its small size and close proximity to Copco 1 Dam. The sediment depth behind the dams varies in each reservoir from 0 feet to greater than 9 feet (Figures 3-2 through 3-4). The variation in sediment depth within and among the reservoirs is caused by differences in flow velocity, depth of the reservoirs, and type of sediment. The downstream portions of the impoundments, where water velocity slows and sediments are able to settle to the bottom, typically contain deeper sediments. Table 3-1 lists the estimated sediment volumes within each reservoir. Copco 2 Reservoir is not included in the table because of the small volume of sediment that it contains.

Figure 3-1. Iron Gate Dam before removal (on top) and a simulation of what the facility could look like after full removal (on the bottom)

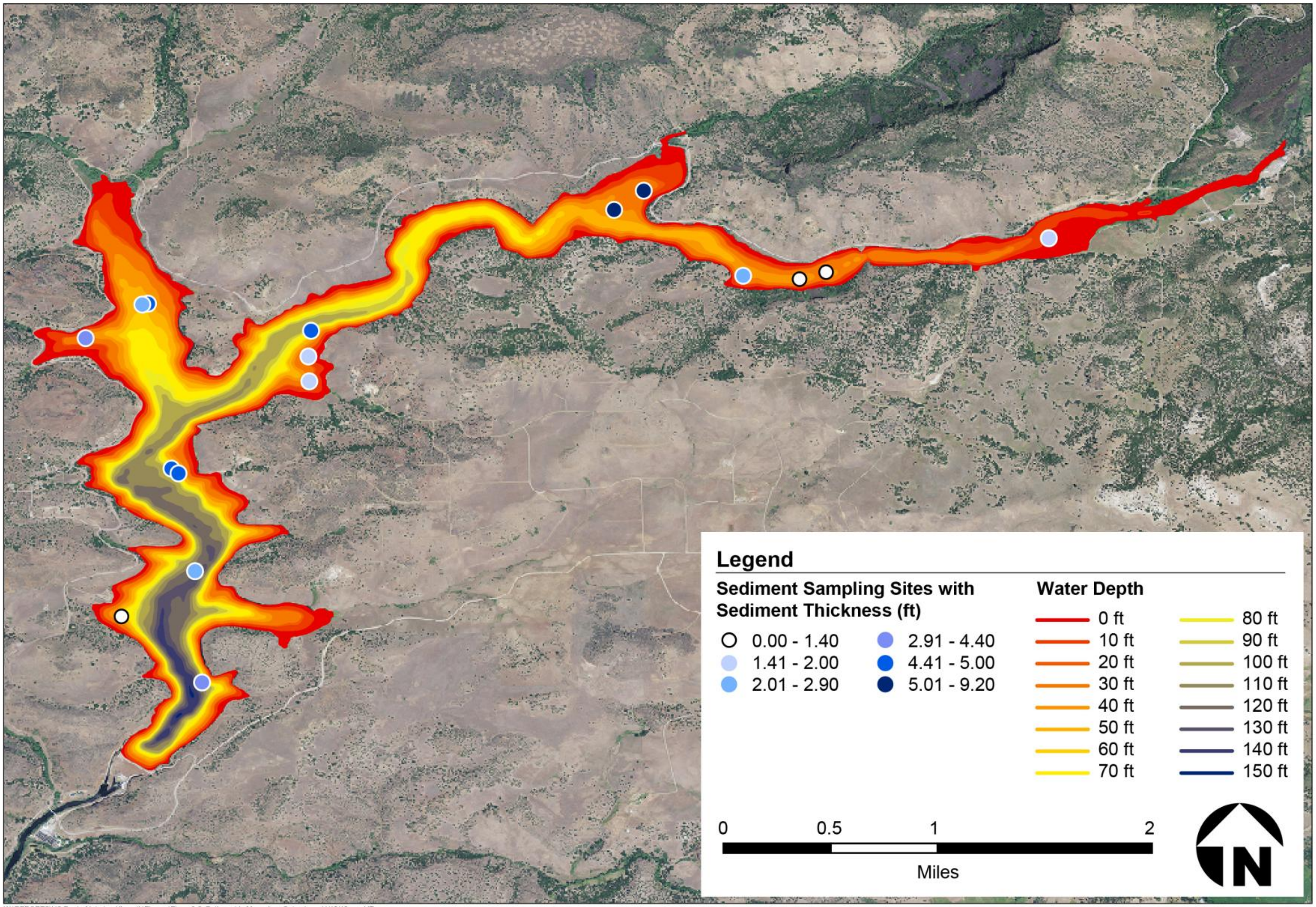

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Figure 3-2. Sediment Thickness at Selected Sites in Iron Gate Reservoir

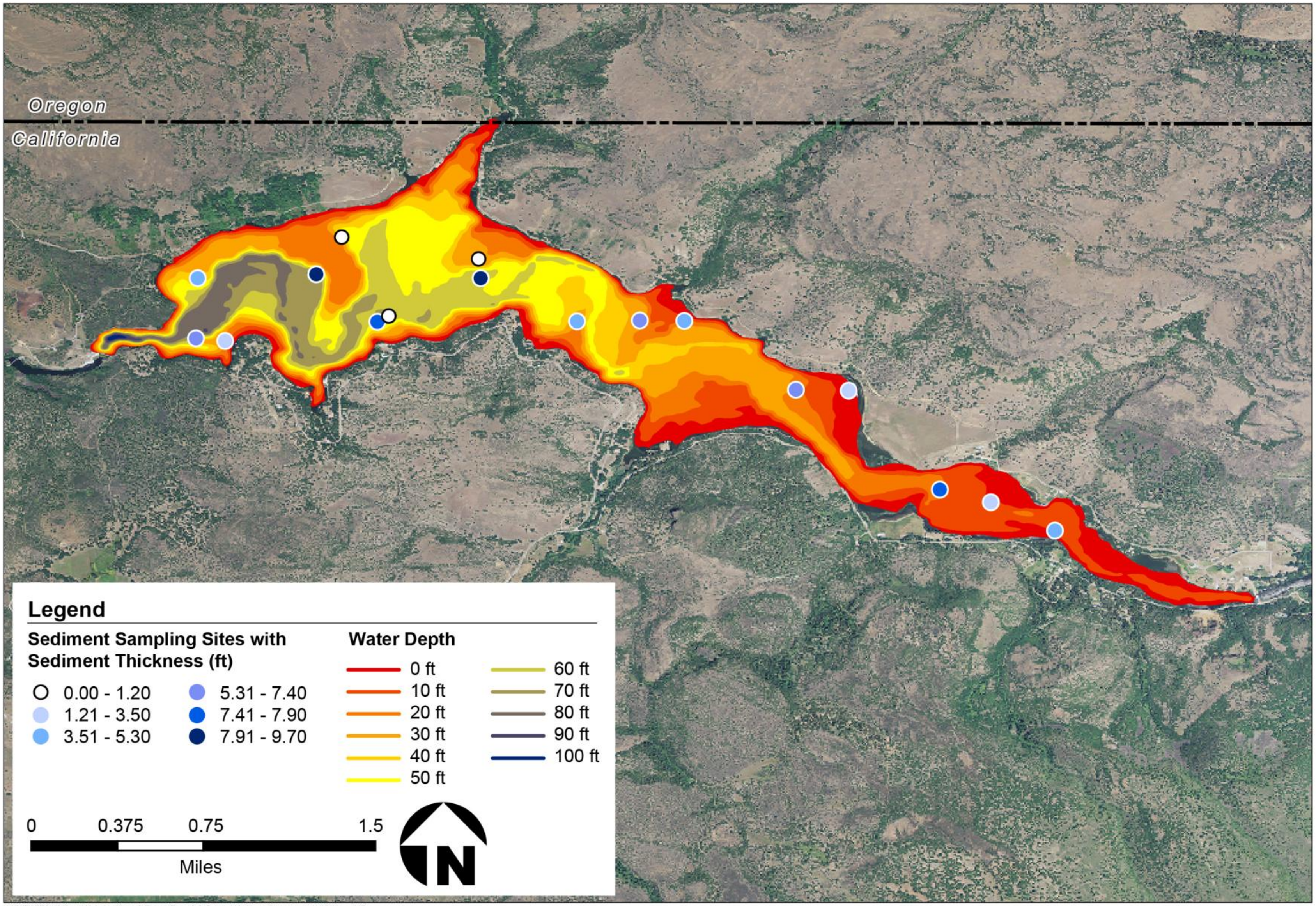

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Figure 3-3. Sediment Thickness at Selected Sites in Copco 1 Reservoir

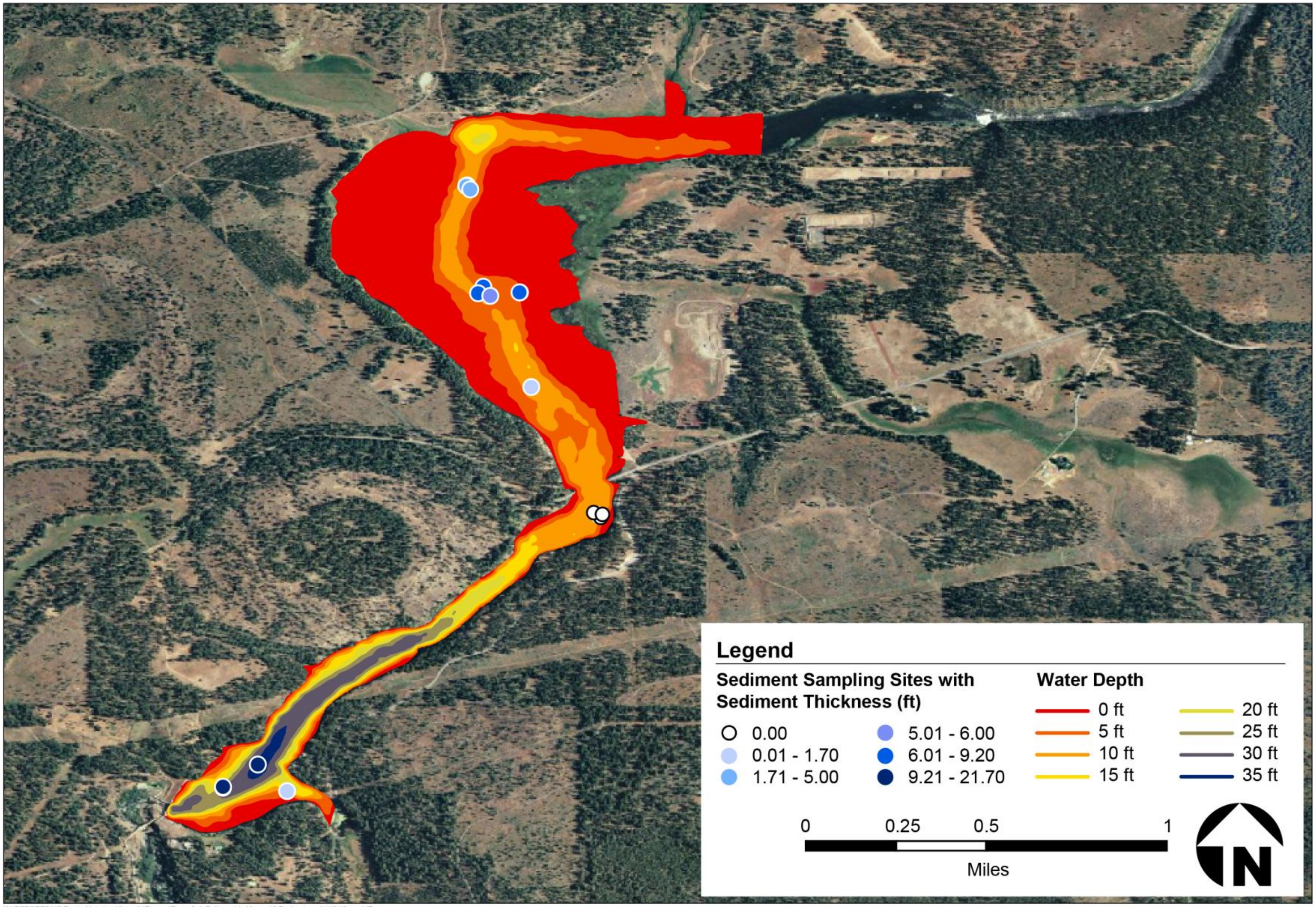

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Figure 3-4. Sediment Thickness at Selected Sites in J.C. Boyle Reservoir

Table 3-1. Accumulated Sediment Volumes

Reservoir	Source area[1] (mi^2)	Period of Sediment Accumulation	Sediment Accumulation Volume (yd^3)
Iron Gate	212	40 yr (1962-2002)	4,700,000
Copco 1	273	84 yr (1918–2002)	7,400,000
J.C. Boyle	225	44 yr (1958–2002)	1,000,000
Total			**13,100,000**

Key:
mi^2: square miles
yd^3: cubic yards
yr: Year
Source: DOI 2011
Notes:
[1] Source Area refers to the sub basin that drains to the reservoir.

Dam removal would release some of the accumulated sediments downstream. The Proposed Action includes the use of erosion from river flows to flush the sediment behind the dams downstream during facility removal. Reservoir drawdown would focus on the wet season in order to flush the sediment downstream with the natural seasonal high flows. Modeling studies indicate that drawdown would erode and flush 41 to 65 percent of the stored sediment downstream (DOI 2011). The initial drawdown would begin slowly, to minimize riverbank erosion, with the rate increasing as water levels drop to maximize the amount of sediment flushed down stream. Most of the sediment remaining on the riverbank slopes would stabilize and would not erode downstream in subsequent years.

3.2.1 Option: Sediment Removal

If analysis indicates that the release of sediment could result in significant effects, the EIS/EIR may include consideration of dredging sediments out of the reservoirs before removing the dams if this measure is determined to be feasible. Dredging would focus on the area within the new river area; sediment remaining above the new stream level would only require removal if the slopes would not be stable. Surveys to date have shown water content in the sediments behind the reservoir to average 80 percent by volume (Eilers and Gubala 2003). Once dredging began, the spoils would be pumped to a detention area near the reservoir for the sediments to dry.

Dredging and the mechanical removal of sediment from the reservoirs would require equipment in addition to that needed for dam removal. This additional equipment would include barges, dredges, and pumps. Storing the spoils after removal from the reservoirs would require an area of sufficient size to allow the sediment to be spread and dried.

3.2.2 KBRA

The KBRA and its component elements are connected actions to the KHSA, and would be a part of the alternatives that include the KHSA. The Proposed Action includes the KBRA and its component elements. The KBRA has three primary goals:

- Restore and sustain natural production and provide for full participation in harvest opportunities of fish species throughout the Klamath Basin;
- Establish reliable water and power supplies which sustain agricultural uses and communities and NWRs; and
- Contribute to the public welfare and the sustainability of all Klamath Basin Communities.

Two sections of the KBRA, the Fisheries Restoration, Reintroduction, and Monitoring Program and the Water Resources Program, outline restoration actions and management activities that would guide restoration and allocate water to environmental and agricultural uses for the duration of the period from the Secretarial Determination through the initiation of facilities removal and beyond. These two programs provide specific goals and actions that work towards meeting the overarching goals of the KBRA outlined above.

The Fisheries Program of the KBRA is intended to accomplish the following:

- Provide for the reintroduction of anadromous species throughout their historic range upstream of Iron Gate Dam, excluding the Lost River sub-basin, and reestablish and maintain the ecological functionality and connectivity of fish habitat.
- Provide for the natural sustainability and genetic diversity of fish species and the overall ecosystem health of the Klamath Basin.
- Establish conditions that provide for the natural sustainability and genetic diversity of fish species and to assess the status, trends, and factors that influence those trends, and assess the effectiveness of the actions mandated under the KBRA.
- Provide for adaptive management based on the assessments of the effectiveness of the restoration actions.

The Fisheries Program currently consists of two planning and implementation phases. Phase I would identify “Investigations, facilities, actions, monitoring, and decisions necessary to initiate and accomplish the reintroduction of anadromous fish species.” Phase II would address the management of the reintroduced fish populations in areas where anadromous fish are currently not present.

The Water Resources Program contains six “Discrete and consistent elements” intended to provide water to the different interests dependent on the Klamath Basin. The KBRA established funds and guidelines for each of these elements, and describes the relationship between these elements:

- On-Project Water Users Program, including provisions related to Tribes and to NWRs

- Off-Project Water Program
- Power for Water Management Program
- Additional Water Conservation and Storage
- Drought, Climate Change, and Emergency
- Environmental Water

The KBRA provides a variety of agreements and assurances between the various signatories and the United States. These agreements and assurances delineate the timeframe of the agreement, the relationships between the different water rights and parties, and the scope and purpose of the different elements and programs created by and described in the document and listed above.

3.3 Alternative 3 – Partial Facilities Removal of Four Dams

This alternative would include removal of the primary structure of the four dams within the streambank to allow the river to achieve a free-flowing condition. Appurtenant structures would remain in place (see Figure 3-5). These features to remain in place could include buildings, power generation facilities, bypass canals and pipelines, and dam foundations. As it would be for Alternative 2, this alternative would include the use of river flow-driven erosion to flush the sediment behind the dams downstream during facility removal. Dredging sediments may be considered. This alternative would also include KBRA implementation (see Section 3.2.2 for more information) and riverbank stabilization within the former reservoir areas.

Figure 3-5. Iron Gate Dam before deconstruction (on top) and a simulation of what the facility could look like after partial facilities removal (on the bottom)

3.4 Alternative 4 – Fish Passage at Four Dams

Under this alternative, the Four Facilities would remain intact and fish passage facilities would be constructed or upgraded to allow volitional fish passage around each of the dams. Iron Gate and Copco 1 Dams are the largest dams under consideration, and these facilities are larger obstacles to fish passage than J.C. Boyle and Copco 2 Dams. Iron Gate Dam has a fish ladder that takes fish to the hatchery, but the ladder does not provide passage around the dam. Copco 1 and Copco 2 Dams do not have fish passage facilities. J.C. Boyle has a pool and weir type fish ladder that would be upgraded to meet state and federal standards. This alternative would require FERC action for implementation and thus is outside of DOI's jurisdiction to implement; however, NEPA requires an agency to study alternatives it does not necessarily have the authority to implement. Implementation of this alternative would require the Hydropower Licensee to obtain a new FERC license to continue operations.

To allow volitional fish passage at each of the dams, facilities must allow both migrating adults to move upstream around the dams to spawn and juveniles to migrate downstream without being drawn into the power house and turbines of the hydroelectric facilities.

To provide for upstream migration, fish ladders require a consistent, cool, and well-oxygenated water supply, an entrance pool, and the actual fishway. Fishways can be "pool and weir" type ladders, wherein a series of stepped pools are constructed that allow adults to swim and jump from one pool to the next, which is the type of ladder that exists at J.C. Boyle (Figure 3-6). Other upstream fish passage designs include aerial trams, where migrating adults are guided into cars on a tram that then transports them up and over the dam to the reservoir. The tram method does not provide "full volitional fish passage" because fish must wait for a tram to arrive before they can move. Ladders allow fish to migrate upstream at will, provided they can find and use the ladder.

On the upstream side, screens may be required at the powerhouse intake and the spillways to prevent juveniles from being swept over the dam or into the turbines. Facilities must also provide for downstream migration. The Fish Passage at Four Dams Alternative includes bypass systems, in which collectors or screens are placed in the reservoir to guide juveniles to the collector. The collector is attached to a pipe that extends to the downstream side of the dam. Downstream passage facilities would need to be constructed at each facility in the project.

W:\REPORTS\US Dept of Interior Klamath\Figures\Figure3-6 Examples of Types of Fishways.ai 11/11/10 JJT

Figure 3-6. Examples of Types of Fishways

3.5 Alternative 5 – Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

This alternative provides for the staged removal of Iron Gate and Copco 1 Dams with construction of fish passage facilities at Copco 2 and J.C. Boyle Dams. Dam removal would occur within a 12-month period once the deconstruction began. This alternative would eliminate peaking power generation at J.C. Boyle Dam. Currently, peaking power generation at J.C. Boyle Dam requires the Copco 1 Reservoir to reregulate flows downstream of the J.C. Boyle peaking reach, because of the large volumes of water used in generating the power. Without Copco 1 Reservoir, river stages would increase rapidly during power generation at J.C. Boyle Dam. Copco 2 Reservoir would not have adequate capacity to absorb these rapid increases in flows. This alternative is outside the DOI's jurisdiction; however, NEPA requires an agency to study alternatives it does not necessarily have the authority to implement. Implementation of this alternative would require the Hydropower Licensee to obtain a new FERC license to generate power at J.C. Boyle and Copco 2 Dams.

Under this alternative, 100 to 200 cubic yards (yd^3) of spawning gravel would be placed downstream from J.C. Boyle Dam to improve spawning habitat in the J.C. Boyle Bypass Reach. This alternative would improve access to habitat for anadromous fisheries by removing Iron Gate and Copco 1 Dams and improving passage at Copco 2 and J.C. Boyle Dams. J.C. Boyle Dam has an outdated fish ladder and outdated fish screens that do not meet current NOAA Fisheries Service fish passage criteria; Alternative 5 would include an upgrade these facilities.

Removal of Iron Gate and Copco 1 Dams would be completed as described for previous alternatives. Reservoir drawdown would begin slowly and would increase in daily flow as the water level dropped in order to maximize the downriver movement of the trapped sediment while minimizing the erosion of the banks of the reservoir.

3.6 Alternative 6 – Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate

This alternative would include removal of Copco 1, Copco 2, and Iron Gate Dams and improvement of fish ladders at J.C. Boyle Dam to provide for full volitional fish passage. This alternative would include full removal of the dams and the appurtenant structures and multiple construction crews to complete the removal within a 12-month period once the deconstruction began. Removal of these three dams would provide free flowing conditions to J.C. Boyle Dam, where improved fish ladders would provide full volitional fish passage upstream and downstream of the facility. This alternative is outside the DOI's jurisdiction; however, NEPA requires an agency to study alternatives it does not necessarily have the authority to implement. Implementation of this alternative would require the Hydropower Licensee to obtain a new FERC license to generate power at J.C. Boyle Dam.

Under this alternative, power generation at J.C. Boyle would continue, although it would not be able to produce peaking power because of the removal of Copco 1 Dam. Currently, Copco 1 Reservoir acts as a regulator for the high flows associated with peaking power generation from J.C. Boyle Dam, in order for the operations to comply with the biological opinions from USFWS and NOAA Fisheries Service. Without Copco 1 Reservoir, the flows from J.C. Boyle would need to conform to the ramping rates and other operational guidelines outlined in the existing biological opinions and agreements, which would preclude peaking power generation without new agreements and guidelines.

3.7 Alternative 7 – Sequenced Removal of Four Dams

The Sequenced Removal of Four Dams Alternative would involve removal of the Four Facilities over a period of three to five years. This alternative would include removal of Iron Gate Dam first, then Copco 1 and 2 Dams at the same time, and finally J.C. Boyle Dam over a period of three years. Copco 2 Dam would be removed at the same time as Copco 1 Dam because of its relatively small size, lack of sediment storage, and proximity to Copco 1 Dam.

Sequencing dam removal could allow small, staged disturbances over several years instead of a single, large disturbance in one year. Construction workers could move from site to site and provide skilled labor. Equipment would also be moved from one site to the next, reducing overall needs. Each dam removal effort would provide an opportunity to adaptively manage the next effort based on lessons learned.

A different removal order was initially considered to allow Iron Gate Reservoir to capture sediment released from upstream dams. However, analysis indicated that the sediment particles were too fine and the retention time within the reservoir too short to allow for settling of a significant amount of sediment (Cui and Orr 2007). Therefore, the focus on determining the order for dam removal became public health and safety. Iron Gate Dam is an earthfill dam that could be the most difficult to remove in a safe manner. It has the highest potential for significant safety issues during dam removal because of the potential for overtopping river flows that could uncontrollably scour the dam material and cause catastrophic failure. In order to minimize this risk to public safety, removing Iron Gate Dam first would provide an opportunity for partial flow regulation and peak flow attenuation upstream at the Copco and J.C. Boyle Developments. Additionally, Section 7.3.7 of the KHSA states "Parties agree that if Decommissioning and Facilities Removal occurs in a staged manner, J.C. Boyle is intended to be the last Facility decommissioned."

3.8 Alternative 8 – Full Facilities Removal of Four Dams without KBRA

The Full Facilities Removal of Four Dams without KBRA would include removal of the Four Facilities within a one-year period. This alternative would return the river to a free-flowing condition and allow volitional fish passage. The details of dam removal would be the same as those described for the Proposed Action. This alternative would not include implementation of the KBRA actions described in Section 3.2.2.

3.9 Alternative 9 – Trap and Haul Fish

This alternative would include modification of the existing hatchery at Iron Gate Dam to include collection, sorting, holding, and loading facilities. This alternative is the same as the FERC staff alternative in the EIS on the Klamath Hydroelectric Project relicensing. The hatchery would still operate, and the Hydropower Licensee would be responsible for all of the operating and maintenance costs of the facility. Migrating adult salmonids would be trapped at Iron Gate Dam and hauled to various release points upstream of J.C. Boyle Dam, including the Williamson and Wood Rivers (upstream of Upper Klamath Lake), to allow salmonids access to potential spawning habitat in the upstream watershed. Adult survival would be monitored using telemetry to monitor the effectiveness of the trap and haul operations. Juvenile salmonids would be trapped at J.C Boyle Dam and hauled to Iron Gate Dam, where they would be marked in a new facility to assess smolt-to-adult survival rates. Monitoring would be employed to find their survival rates from the trapping phase through holding and release. Multiple release points for the juveniles would be used, and survival monitoring would provide data for adaptive management efforts.

In addition to the trap and haul operation, this alternative would include several monitoring and management efforts to improve water quality, reduce fish disease, and improve smolt survival during their outmigration. These efforts would include releasing cooler water from Iron Gate Reservoir to lower downstream water temperature, maintaining flows downstream of J.C. Boyle Dam to increase usable fish habitat, placing spawning gravel upstream of J.C. Boyle and downstream of Iron Gate Dam to improve salmonid habitat, and installing flow gages and water quality monitoring equipment to measure the effectiveness of the efforts.

This alternative would not include fish passage facilities at any of the dams or modifications to the operations of the hydroelectric facilities. As discussed for the No Action/No Project Alternative, the NOAA Fisheries Service biological opinion would govern flows and provide some limits on power operations. Implementation of this alternative would require the Hydropower Licensee to obtain a new FERC license to continue operations.

3.10 Alternative 10 – Fish Bypass: Bogus Creek Bypass

This alternative would include development of an approximately 13-mile route for migrating anadromous fish to bypass three of the four dams on the main stem of the Klamath and access upstream spawning habitat. J.C. Boyle Dam would also need improvements to the fish passage structures to allow upstream and downstream passage. Under this alternative, power production would continue as in the No Action/No Project Alternative, under which the NOAA Fisheries Service biological opinion would govern flows and limit power operations. Implementation of this alternative would require the Hydropower Licensee to obtain a new FERC license to continue operations.

This alternative would include creation of a migratory bypass around the dams using Bogus Creek and a constructed canal to connect the headwaters of Cold Creek with the headwaters of Little Deer Creek (Figure 3-7). The headwaters of Cold Creek, which flows into the headwaters of Bogus Creek, are about three miles from Little Deer Creek, which flows into the Copco 1 Reservoir. This design would allow up-migrating salmonids to swim upstream in Bogus Creek to its confluence with Cold Creek, then upstream in Cold Creek to the constructed canal. The fish would proceed downstream through the canal to Little Deer Creek and into Copco 1 Reservoir (CDFG 2009). Juvenile salmonids migrating downstream would follow the same route in reverse.

The 3.2-mile canal would connect Cold Creek with Little Deer Creek, and be partially supplied with water from Cold Creek. The alternative would require the construction of a 2.3-mile pipeline and the installation of a 1,500 horse power recirculating pump to lift the water approximately 500 feet from Copco 1 Reservoir through the pipeline to the confluence of the canal and Little Deer Creek. The pipeline would take water from Copco 1 Reservoir and use it to feed the lower portion of the canal and increase flows in Little Deer Creek to accommodate the migrating salmonid population.

Bogus Creek is a small stream, with an average width in the lower reaches of 15 feet and pools about four feet deep. It becomes smaller in its upper reaches where it connects with Cold Creek, which has an average width of six to eight feet and an average depth of only eight to twelve inches. Deer Creek is similar in size to Cold Creek, and steeper. Depth and gradient is a limiting factor for salmonids, with both coho and Chinook tending to spawn in streams with gradients less than three percent (CDFG 2009). The gradients in the upper reaches, where the canal is proposed, exceed this slope, and neither coho nor Chinook are typically seen in the upper portions of the watershed.

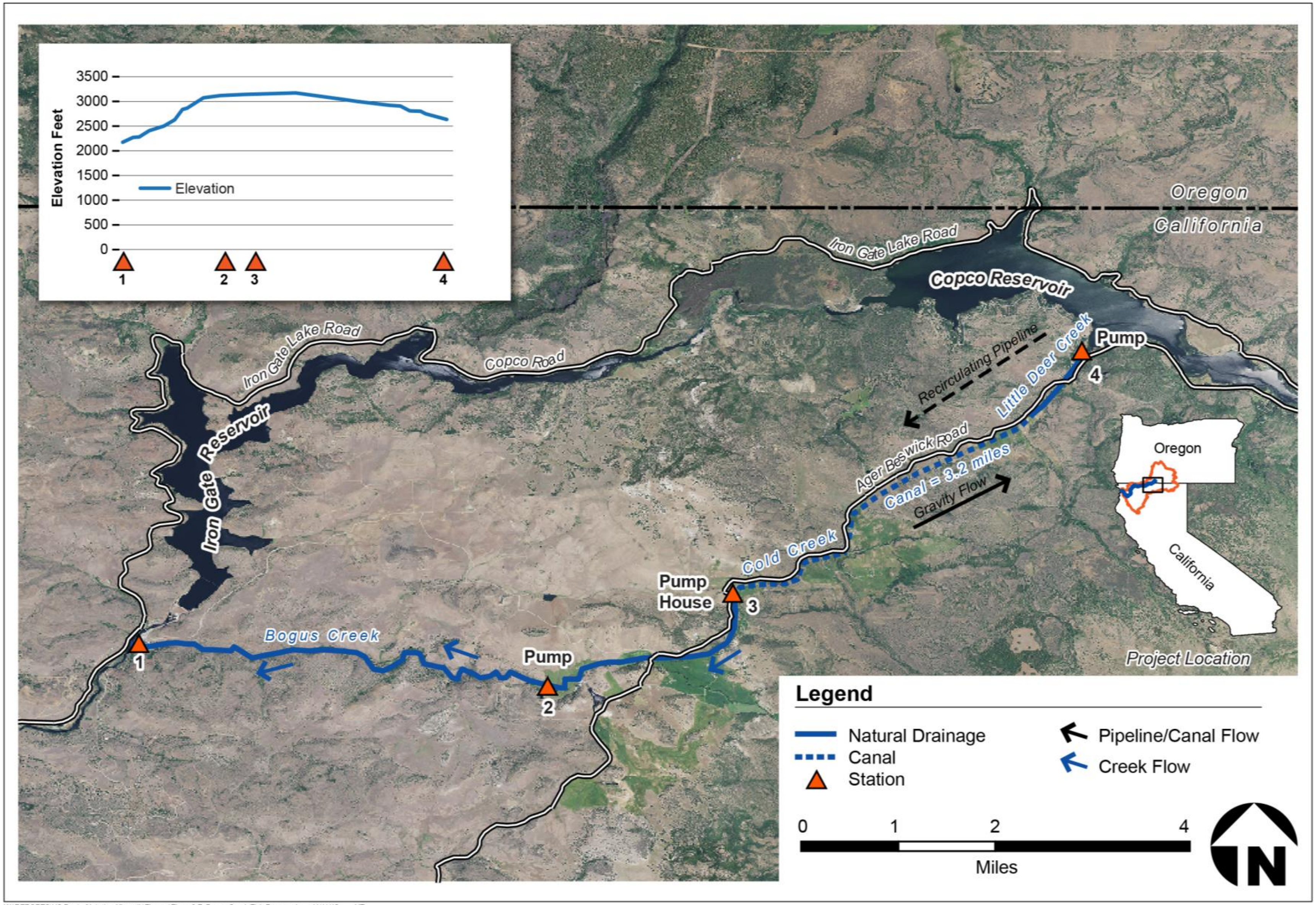

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Figure 3-7. Bogus Creek Fish Bypass

Bogus Creek enters the Klamath River just downstream of the Iron Gate Dam, and is used by salmonids as spawning habitat. The Bogus Creek Bypass Alternative includes a variety of habitat improvements in Bogus Creek, Cold Creek, and Little Deer Creek, and constructed habitat in the canal. Habitat in Bogus Creek would be improved by adding spawning gravel and other habitat elements between the confluence of the creek at the Klamath River and the entrance to the proposed canal. This alternative would include construction of refugia in other areas along Cold Creek, the canal, and Little Deer Creek to improve the habitat for migrating salmonids, and to encourage spawning in the Bypass. Refuge areas would be created or augmented where smaller creeks enter the Bypass route as they provide cold water sources, and could provide thermal refugia for migrating adults.

There are two existing fish ladders on the proposed route: one in Bogus Creek at stream mile 3.6 to pass fish around a natural, 22-foot waterfall, and one in Cold Creek at stream mile 0.6 at a naturally occurring 9-foot waterfall (CDFG 2009). These existing ladders are insufficient to pass large numbers of migrating salmonids, and would have to be upgraded to accommodate the potential increase in the size of the fish migration.

3.11 Alternative 11 – Fish Bypass: Alternative Tunnel Route

This alternative would use a combination of natural drainages and a constructed tunnel to provide a migratory passage for anadromous species around Copco 1, Copco 2, and Iron Gate Dams while leaving the dams in place. This alternative also includes improvements to fish passage facilities at J.C. Boyle Dam to allow upstream and downstream passage. This alternative would allow continued power generation at the Four Facilities, but the Hydropower Licensee would need to obtain a new FERC license to continue operations.

This alternative bypass would route upmigrating fish into Bogus Creek into an approximately five-mile tunnel that would connect Bogus Creek to Copco 1 Reservoir. The tunnel would connect to Bogus Creek at stream mile 2.9, well downstream of the existing fish ladder on the creek and the confluence with Cold Creek (Bacigalupi and Lake 2010) (Figure 3-8).

The proposed tunnel would be 16 feet wide by 12 feet high and would contain a 4 foot wide by 2 foot deep fish channel on one side. Larger “rest areas” for the migrating fish would be placed every 250 feet, and vertical shafts would be installed at regular intervals to provide natural light to the channel (Bacigalupi and Lake 2010). The proposed gradient of the channel would be less than one percent, and flow would be above 10 cfs.

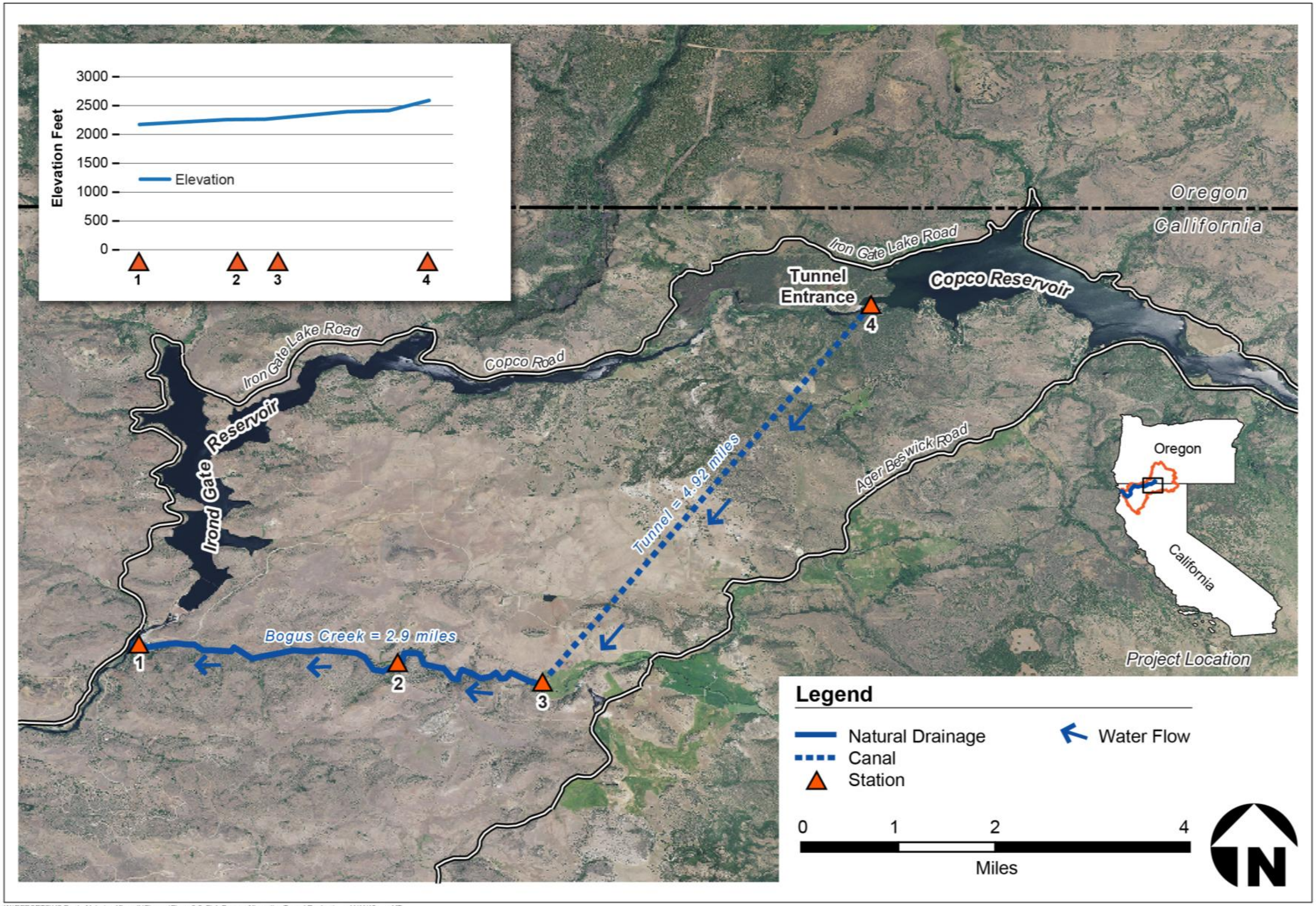

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Figure 3-8. Fish Bypass Alternative Tunnel Route

A floating entrance structure at Copco 1 Reservoir would provide water and fish access to the tunnel. The structure would float with the level of the lake to provide a year round water supply regardless of the level of the reservoir, as well as serve as the access to the tunnel for anadromous species.

The proposal addresses some of the issues associated with Alternative 10, the Bogus Creek Bypass route: the tunnel would allow migrating salmonids to swim in a consistently upstream direction, as the tunnel would be drilled to connect the reservoir with the downstream tributary. In addition, it would not require a new water supply or negotiations, as would the bypass in the fully appropriated Cold Creek (in Alternative 10), because water for Alternative 11 would be supplied from Copco 1 Reservoir. Finally, the tunnel might provide more capacity for the large numbers of migrating salmonids than the smaller drainages of Clear and Deer Creeks.

3.12 Alternative 12 – Notching of Four Dams

This alternative includes notching J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams as an alternative to full or partial removal of the Four Facilities. The work would involve cutting concrete and excavating earthen material from the middle of the dams down to the river bed to create a "free-flowing condition." This process would leave portions of each dam intact on either side of the river, along with many of the appurtenant structures (see Figure 3-9). The appurtenant structures would be retired, but left in place.

Under this alternative, more material would remain in place than with the partial removal alternatives. Powerhouses, diversion canals, and other facilities would also remain in place. The material left in place would either be hardened with large rock or material from the removed portions of the dam, or left to erode downstream.

3.13 Alternative 13 – Federal Takeover of Project

Under this alternative, the federal government takes control of the dams under the authority of the Federal Power Act. The intent of the Federal Takeover Alternative would be to fast track the removal of the Four Facilities. Under this alternative, the federal government would fund the removal costs, rather than dam removal being funding as described in the KHSA.[3]

[3] Under the KHSA, dam removal would not begin until 2020 in order to provide an adequate opportunity to raise funds to pay for the dam deconstruction. The KHSA indicates that the Public Utilities Commissions of both Oregon and California would establish customer surcharges on PacifiCorp's customers with the express purpose of raising funds for dam removal. The Oregon surcharge has been approved and implemented. The California Legislature has agreed to put a general obligation bond before the voters in November 2012 to fund the difference between the customer contribution and the actual cost of dam removal. All funds that are acquired during the period from the Secretarial Determination until the beginning of facilities removal would be managed and dispersed by a trustee.

Photos by: Scott Wright, River Design Group, Inc. (2008)

W:\Office\Sacramento\Klamath River Dam Removal\Figure3-9_Example of Dam Notching Technique - Before and After.ai 01/10/11 JJT

Figure 3-9. Example of Dam Notching Technique, Before and After

Any Federal takeover would require Congressional approval, development of mitigation plans, and actions to secure permits that would require an in-depth environmental review process by federal and state agencies. The federal government has no plan for a takeover of the facility. Developing and implementing such a plan would involve many of the same design and permitting steps as the KHSA. The timeline would likely not be expedited substantially from the timeframe specified in the KHSA.

The federal takeover would still involve the full removal of the Four Facilities, requiring the same deconstruction activities under this alternative as in Alternative 2. Alternative 13 would differ from Alternative 2 in its lack of implementation of some elements of the KBRA, its source of funding for the project, and its timeline for completion.

3.14 Alternative 14 – Full Removal of Five Dams

This alternative would involve removal of Keno Dam in addition to the Four Facilities. The intent of this alternative would be to further expand the amount of habitat available to anadromous species, and would include the full removal of Keno Dam, the power generation facilities, bypass canals, pipelines, and dam foundations. This alternative would include the use of natural sediment flushing to move deposited sediment downstream, similar to Alternative 2, and would include riverbank restoration and revegetation within the areas of the former reservoirs.

Keno Dam is at River Mile (RM) 233, approximately 20 miles downstream from Link River Dam. There is no power generation at Keno Dam. The Keno facilities include a fish ladder suitable for trout and salmon passage. The Keno Impoundment provides irrigation supplies to the Lost River Diversion Channel, which serves the Ady and North Canals, the Klamath Drainage District, Area K Lease lands, and the Lower Klamath NWR. The removal of Keno Dam and Impoundment would require the construction of new irrigation infrastructure to replace the storage and conveyance facilities currently in place. Facilities to replace supplies would need to either pump from the river in a nearby location, or convey water from Upper Klamath Lake. New infrastructure would include pumps and pipelines to transport the water and modifications to the existing canals to accept water from the new sources.

3.15 Alternative 15 – Full Removal of Six Dams

This alternative would involve removal of Keno and Link River Dams in addition to the Four Facilities. The six dams would be fully removed, with all portions of the dams, hydroelectric facilities, and appurtenant structures being decommissioned. Keno Dam would be removed as described for Alternative 14, but this alternative would also include removal of Link River Dam. Like Alternative 14, this alternative includes natural sediment flushing, bank stabilization, and revegetation efforts within the former reservoir sites.

The Link River Dam is a concrete slab structure with a crest length of 435 feet. The structure stands 22 feet high and is 7 feet wide at the top. Link River Dam's reservoir, Upper Klamath Lake, has a total capacity of 873,000 acre-feet. Upper Klamath Lake provides water for the downstream hydroelectric facilities and irrigation needs, and regulates water levels to comply with the USFWS biological opinion on the shortnose and Lost River suckers. Link River Dam is 253.7 river miles up the Klamath River from its mouth, at the downstream end of Upper Klamath Lake. This facility has a state-of-the-art fish ladder suitable for trout, suckers, and anadromous fish migrations. This alternative would also require the construction of new conveyance and storage facilities for dependent irrigators and NWRs, and could result in a lack of water supplies to meet the requirements of the biological opinion for the suckers.

3.16 Alternative 16 – Dredge Upper Klamath Lake

The intent of this alternative would be to improve water quality in the Klamath Basin by dredging and removing phosphorous-rich sediments from Upper Klamath Lake. Ortho-phosphate, an agricultural fertilizer, helps fuel algae blooms that reduce the amount of oxygen available for other aquatic species. Reducing the supply of phosphorous to Upper Klamath Lake could improve the quality of water discharged downstream, although other naturally-occurring phosphorus sources would remain.

The dredging could also increase the storage capacity of Upper Klamath Lake, offering the potential to increase supplies and reduce the competition for limited water supplies among the irrigators, wildlife refuges, and environmental needs downstream of the lake.

This alternative would not involve removal of any dams, and thus would maintain the hydroelectric generating capacity of the Klamath Hydroelectric Project. It does not provide for fish passage at these facilities; therefore, implementing this alternative would not open any spawning areas or salmonid habitat.

3.17 Alternative 17 – Predator Control

This alternative would include control of seal, sea lion, and cormorant populations at the mouth of the Klamath River as an alternative to dam removal. It has been suggested that predation of anadromous salmonids by these marine species is having a major effect on the salmonid population as they return to the Klamath River to spawn. A number of seal and sea lion haul outs and sea bird colonies exist in the vicinity of the mouth of the Klamath (Figure 3-10).

Since the passage of the Marine Mammal Protection Act in 1972, marine mammal populations have recovered, and are considered "healthy and robust" (NOAA Fisheries Service 2008a). Proponents of predator control claim that the recovered predator population is increasing the pressure on salmonids because of unbalanced numbers of predators compared to the still depressed salmonid population numbers. Salmon waiting to enter the Klamath for their upstream migration congregate at the mouth of the river, where the marine predators are able to feed easily on the schools of fish.

A study (Wiese, et al. 2008) examined the effects that avian predators, such as gulls, cormorants, and certain species of ducks, have on out-migrating smolts in the Columbia River at reservoirs. Smolts congregate in reservoirs as they attempt to find fish passage infrastructure on their way to the ocean, making them easy targets for resident piscivorous birds. The study concluded that predatory birds in the reservoirs accounted for the mortality of less than one percent of the juvenile salmonid population. Similar percentages may be expected as juvenile salmonids pass down river into the ocean.

3.18 Alternative 18 – Partition Upper Klamath Lake

This alternative was a suggestion intended to increase the amount of active storage in Upper Klamath Lake, which could reduce competition for water by increasing the available supply. The concept behind this alternative is to create an “inner lake” in Upper Klamath Lake by constructing a new levee in the middle of the existing lake (Figure 3-11). The new reservoir would capture excess winter and spring runoff, and be fed throughout the summer by natural springs.

The proposed levee would be approximately 50 feet wide and 40 feet tall, and would enclose a body of water approximately three miles wide by eight miles long, with an expected capacity of 400,000 acre feet (Herald and News 2010). In addition, the new lake would be dredged, further increasing the holding capacity of the new storage facility by deepening the reservoir.

The new supply of water would be used to provide consistent irrigation supplies while still providing adequate water for downstream beneficial uses, which include power generation, recreation, and environmental needs in the Klamath River and the nearby wildlife refuges.

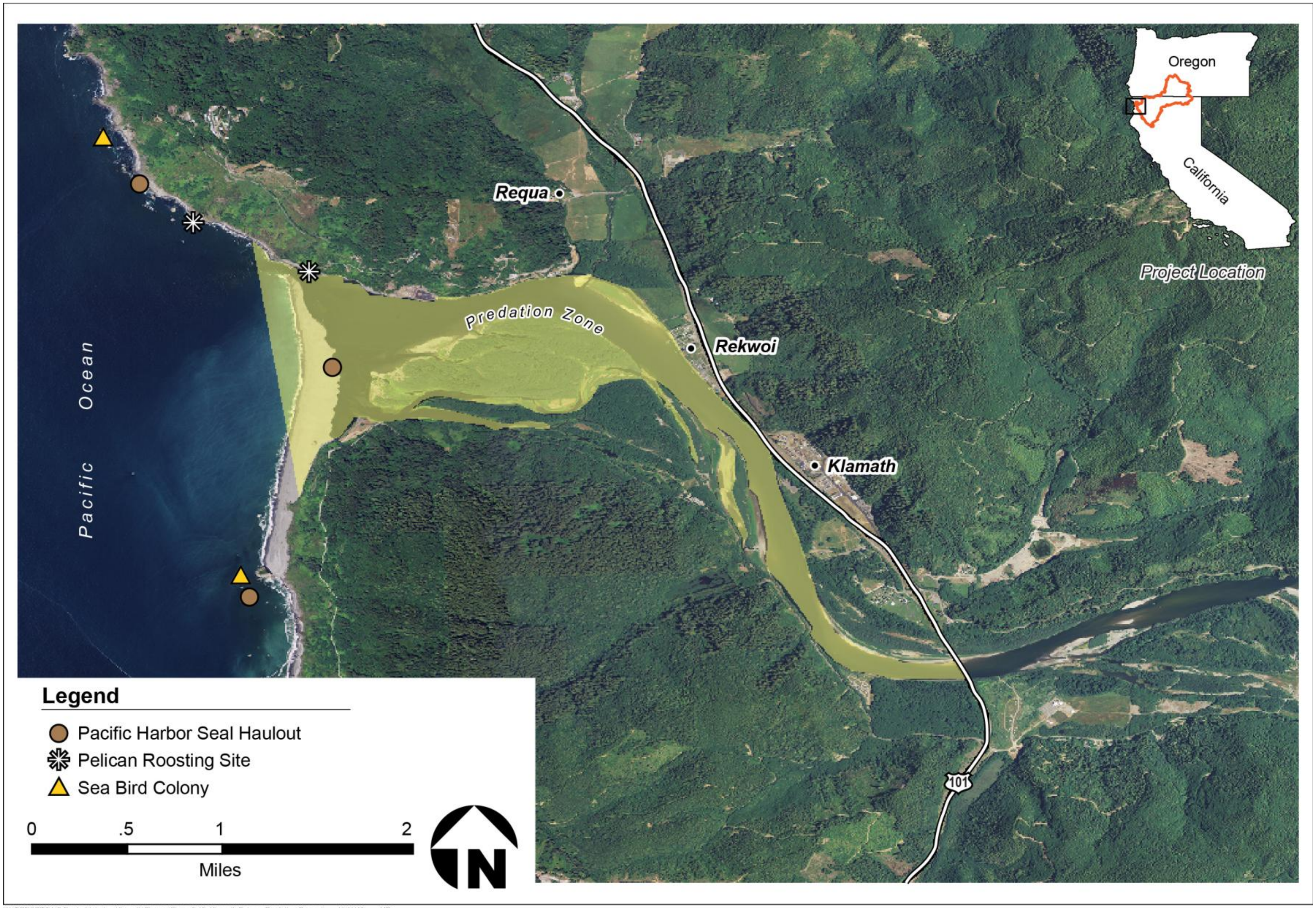

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Figure 3-10. Klamath Estuary Predation Zone

Figure 3-11. Proposed Inner Lake in Upper Klamath Lake

Chapter 4
Alternatives Screening

4.1 Screening Evaluation

The screening considerations described in Section 2.3 were applied to all alternatives and given a rating, described as follows:

1. Green: The alternative meets the screening consideration.

2. Yellow: The alternative does not meet the screening consideration.

3. White: More information is necessary to determine whether the alternative meets the screening consideration.

4.2 Screening

This section presents the screening evaluation for the alternatives. Each alternative discussion includes a table that indicates whether the alternative meets each consideration or requires more information for analysis. The tables list the major influencing factors that affected the rating determination. The influencing factors are based on available data and studies and best professional judgment.

4.2.1 Alternative 1 – No Action/No Project Alternative

NEPA and CEQA require inclusion of the No Action/No Project Alternative; therefore, this alternative will be carried forward for more detailed analysis in the EIS/EIR.

4.2.2 Alternative 2 – Full Facilities Removal of Four Dams (Proposed Action)

Alternative 2 would involve full implementation of the KHSA and the KBRA elements. It would fully meet the purpose and need/project objectives. Table 4-1 summarizes the results of the evaluation of the Proposed Action according to the screening considerations.

Table 4-1. Screening of Alternative 2: Full Facilities Removal of Four Dams Alternative (Proposed Action)

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would meet requirements of both agreements	Meets consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed and include restoration actions in KBRA to advance restoration	Meets consideration
Reliable water supplies	Would establish diversion patterns based on year types in the KBRA to improve reliability of water supplies	Meets consideration
Reliable power supplies	Would implement power program to ensure reliable electricity at affordable rates	Meets consideration
Improve long-term water quality	Would create free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

The Proposed Action meets all of the screening considerations. It is possible to engineer and execute the deconstruction of the Four Facilities. The task of planning and designing the deconstruction project would be complicated by the presence of sensitive aquatic species and the KHSA requirement to remove the dams in one year; however, dam removal is feasible.

With respect to the “Improve long-term water quality” consideration, water quality in the Klamath River downstream of the Klamath Hydroelectric Project might be reduced temporarily by the release of reservoir sediments, which would flow downstream as the dams are removed. The suspension of sediments in the water column, and other associated water quality parameters, could adversely affect aquatic species, including ESA- and CESA-listed fish. If necessary and feasible, mechanically removing a portion of reservoir sediment could reduce the potential adverse water quality impacts of sediment release. Sediment removal could cause impacts. In particular, dredging sediments could damage cultural or historic resources buried under the sediment. The feasibility of conducting mechanical sediment removal is uncertain at this time (for instance, the engineering details, such as equipment access, locations where sediment can drain, and disposal locations would need to be determined and analyzed). Dredging three reservoirs prior to dam removal and in accordance with the KHSA would take additional time, possibly more than the current one-year dam removal schedule.

Alternative 2 meets all the screening considerations and therefore **will be retained for further evaluation in the EIS/EIR**.

4.2.3 Alternative 3 – Partial Facilities Removal of Four Dams

Similar to Alternative 2, Alternative 3 would involve full implementation of the KHSA and KBRA elements. In contrast to Alternative 2, Alternative 3 would include removal of J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams, but would allow for some appurtenant structures to remain on site. Alternative 3 would fully meet the purpose and need/project objectives. Table 4-2 summarizes the evaluation of the Partial Facilities Removal Alternative according to the screening considerations.

Table 4-2. Screening of Alternative 3: Partial Facilities Removal of Four Dams Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would meet requirements of both agreements	Meets consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed and include restoration actions in KBRA to advance restoration	Meets consideration
Reliable water supplies	Would establish diversion patterns based on year types in the KBRA to improve reliability of water supplies	Meets consideration
Reliable power supplies	Would implement power program to ensure reliable electricity at affordable rates	Meets consideration
Improve long-term water quality	Would create free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

The Partial Facilities Removal Alternative addresses all of the screening considerations. Implementation of this alternative would require long-term maintenance of any remaining facilities. As discussed in Section 4.2.2 (Alternative 2), mechanical sediment removal could be included in Alternative 3 to reduce impacts of sediment release, if necessary and feasible. Notwithstanding its potential to lessen the adverse impacts on water quality, dredging sediment might cause adverse impacts on other resources.

Alternative 3 meets all the screening considerations and therefore **will be retained for further evaluation in the EIS/EIR.**

4.2.4 Alternative 4 – Fish Passage at Four Dams

Alternative 4 would not involve the removal of any dam facilities and thus neither the KHSA nor the KBRA would be implemented. Instead, this alternative would involve construction of fishways at each of the four dams. Table 4-3 summarizes the evaluation of the Fish Passage at Four Dams Alternative according to the screening considerations.

Table 4-3. Screening of Alternative 4: Fish Passage at Four Dams Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not remove any of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would provide full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed for salmonid restoration	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality	Does not meet consideration
Technically feasible	Would be technically feasible	Meets consideration

The Fish Passage at Four Dams Alternative does not meet most of the screening considerations. The alternative would not result in a free-flowing river, although it would provide for full volitional fish passage and therefore would advance salmonid restoration. The design and construction of fishways for the dams, specifically the very tall dams at the Iron Gate and Copco 1 Developments, would be technically difficult due to the length of facility needed to reach the top of the dam. Fish would need to expend a substantial amount of energy to climb these fishways. The design will focus on providing full volitional fish passage, and this alternative would be technically feasible.

Because the KHSA would not be implemented as the terms and conditions require, the KBRA and its elements would also not be implemented, as they are dependent connected actions. Programs under the KBRA, such as those addressing reliable water supplies or power, would not be implemented. While the hydropower facilities would continue to generate power as part of this alternative, future rates are uncertain and elements of the KBRA intended to provide reliable long-term power at affordable prices would not be implemented. This alternative would not include elements that would improve water quality compared to the No Action/No Project Alternative.

Although Alternative 4 would not meet the purpose and need of the action or most of the objectives, it **will be retained for further evaluation in the EIS/EIR** because it could lessen potential construction-related environmental and power generation effects of the Proposed Action. Additionally, multiple commenters suggested that it be retained. Alternative 4 provides a comparison of what is most likely to be implemented if the FERC FEIS were implemented. Furthermore, a comparison of effects will be informative.

4.2.5 Alternative 5 – Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Alternative 5 includes removal of the dams and appurtenant structures at the Iron Gate and Copco 1 Developments, and construction of (or improvements to) fishways at Copco 2 and J.C. Boyle Dams. Alternative 5 would not involve implementation of the KHSA or the KBRA elements as the terms and conditions require, because only two of the four dams would be removed. Table 4-4 summarizes the evaluation of Alternative 5 according to the screening considerations.

Table 4-4. Screening of Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would remove only two of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Removes two dams and adds ladders to two dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Provides access to more of the watershed	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would improve degraded water quality caused by Iron Gate and Copco 1 Dams	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

Alternative 5 does not meet most of the screening considerations. The alternative would not result in a completely free-flowing river, although it would result in more of the river open for free-flowing conditions. Implementation of Alternative 5 would improve water quality because the reservoirs behind Iron Gate and Copco 1 Dams degrade water quality on the river. Because the KHSA requirements would not be met, the KBRA and its elements would not be implemented as dependent connected actions. Programs under the KBRA, such as those addressing reliable water supplies or power, would not be implemented as part of Alternative 5.

Although Alternative 5 does not meet most of the screening considerations, it **will be retained for further evaluation in the EIS/EIR** because this alternative has the potential to reduce construction-related environmental and power generation effects associated with deconstruction.

Implementation of the alternative would improve water quality and provide for additional fish habitat while still providing some power generation. Additionally, it would lessen water quality effects of the two larger reservoirs. Inclusion of this alternative helps create a reasonable range of alternatives.

4.2.6 Alternative 6 – Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate

Alternative 6 would not involve full implementation of the KHSA or the KBRA and its component elements because it would involve removal of three of the four dams under consideration. Table 4-5 summarizes the evaluation of Alternative 6 according to the screening considerations.

Table 4-5. Screening of Alternative 6: Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would remove only three of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Removes three dams and upgrades passage facilities at J.C. Boyle Dam to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Provides access to more of the watershed	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would improve degraded water quality caused by Iron Gate and Copco 1 Dams	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

Alternative 6 would not meet all of the screening considerations. Implementation of this alternative would not result in a free-flowing river, but would achieve full volitional fish passage and would therefore advance salmonid restoration. Because the KHSA and KBRA requirements would not be met, several of the programs under the KBRA would not be implemented to provide reliable water or power supplies.

This alternative would be likely to improve water quality. The effects associated with dam removal and fish ladder construction will be addressed for the Full Facilities Removal (Alternative 2), Fish Passage at Four Dams (Alternative 4), and Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate (Alternative 5) Alternatives. The EIS/EIR will include full analyses regarding the effects of removing all dams, laddering all dams, and a combination of these measures. The environmental effects of Alternative 6 would be fully analyzed through these other alternatives; therefore, it **will not be retained for analysis in the EIS/EIR as a separate alternative**.

4.2.7 Alternative 7 – Sequenced Removal of Four Dams

Alternative 7 would involve sequencing the deconstruction of each dam over a period of three to five years and would include implementation of the KBRA. Table 4-6 provides the evaluation of the Sequenced Removal of Four Dams Alternative according to the screening considerations.

Table 4-6. Screening of Alternative 7: Sequenced Removal of Four Dams

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would meet requirements of both agreements	Meets consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would release sediment stored in reservoir over a period of multiple years, which would adversely affect multiple years of salmonids	Does not meet consideration
Reliable water supplies	Would establish diversion patterns based on year types in the KBRA to improve reliability of water supplies	Meets consideration
Reliable power supplies	Would implement power program to ensure reliable electricity at affordable rates	Meets consideration
Improve long-term water quality	Would create free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

While the KHSA specifies a one-year timeframe for deconstruction, it also includes clauses that the agencies could meet and confer on a different schedule. Alternative 7 would be consistent with the KHSA because of this clause.

The Sequenced Removal of Four Dams Alternative would result in a free-flowing river and would include the restoration actions of the KBRA; therefore, it addresses most of the screening considerations. Sequencing removal over three to five years, however, would lengthen the amount of time that high concentrations of suspended sediment would be in the Klamath River. Under the Proposed Action, the sediment release could result in adverse effects to focal fish species, but the focal fish species are predicted to have a strong recovery because they would not have an entire year-class exposed to multiple months of high suspended sediments. Extending the sediment release over multiple years would increase both adults as they migrate upstream and their progeny when they migrate downstream in subsequent years. Impacts to focal fish species would be greater because the sediment would affect multiple life-stages of fish over multiple years (Stillwater Sciences 2011).

Alternative 7 **will not be carried forward for more detailed analysis in the EIS/EIR** because it would not avoid or lessen the significant environmental effects of the Proposed Action and may increase effects to fish associated with sediment release from the reservoirs over multiple years. Removing the facilities over multiple years could increase adverse effects on fishery resources. Alternative 7 is similar to Alternatives 2 and 3, except for the possibility of increased adverse effects on the salmonids, as advancing restoration of salmonids is an essential consideration, and this alternative does not present a reasonable means of doing so, as compared to Alternatives 2 and 3.

4.2.8 Alternative 8 – Full Facilities Removal of Four Dams without KBRA

Alternative 8 would include full removal of the Four Facilities, but it would not include implementation of the actions in the KBRA. Table 4-7 summarizes the evaluation of the Full Facilities removal of Four Dams without KBRA Alternative according to the screening considerations.

Table 4-7. Screening of Alternative 8: Full Facilities Removal of Four Dams without KBRA Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not implement the KBRA	Does not meet consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would create a free-flowing river, which would reduce quality concerns within existing reservoirs	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

Alternative 8 would satisfy several screening considerations through removal of the four dams and returning the river reach to a free-flowing condition. This alternative would not, however, include the KBRA or its associated benefits, such as improvements to reliability of water and power supplies. Removing the four dams would improve water quality because the existing reservoirs would no longer cause impaired water quality; however, this alternative would not include the water quality benefits from the KBRA.

Alternative 8 **will not be carried forward for more detailed analysis in the EIS/EIR** because it does not meet the purpose and need under NEPA or the project objectives under CEQA and would not avoid or lessen significant environmental effects of the Proposed Action. The impacts from dam removal would be the same as the Proposed Action, but the restoration elements of the KBRA would not provide benefits to help offset these environmental effects.

4.2.9 Alternative 9 –Trap and Haul Fish

Alternative 9 would include construction and management of fish trapping and hauling facilities; it would not include implementation of the KHSA or the KBRA and its component elements. Table 4-8 summarizes the evaluation of the Trap and Haul Fish Alternative according to the screening considerations.

Table 4-8. Screening of Alternative 9: Trap and Haul Fish Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not remove any of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not provide for volitional fish passage	Does not meet consideration
Advance restoration of salmonids	Unknown whether the alternative would be effective to allow salmonids to thrive in the upper watershed	Needs more information
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality with dams still in place	Does not meet consideration
Technically feasible	Is technically feasible	Meets consideration

The Trap and Haul Fish Alternative would not meet all of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for full volitional fish passage. Although it is unknown whether the trapping and the relocation of fish would provide the opportunity for the advancement of salmonids, it has been shown to be an ineffective technique (CDFG 2006). Because the KHSA and KBRA would not be implemented under the alternative, several of the programs under the KBRA would not be implemented to provide reliable water or power supplies.

Alternative 9 **will not be retained for more detailed analysis in the EIS/EIR** because it does not meet the purpose and need under NEPA or most of the program objectives under CEQA. Additionally, much of what is presented in this alternative is already covered by other alternatives.

4.2.10 Alternative 10 – Fish Bypass: Bogus Creek Bypass

Alternative 10 would involve the construction of a fish bypass around the dams in lieu of dam removal. This alternative would not include implementation of the KHSA; therefore, the KBRA and its component elements would not be implemented because they are dependent connected actions. Table 4-9 summarizes the evaluation of the Fish Bypass: Bogus Creek Bypass Alternative according to the screening considerations.

The Fish Bypass: Bogus Creek Bypass Alternative would not meet any of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for the full volitional passage of fish. The alternative would involve the use of mechanical assistance for fish passage because fish would need to be physically moved at the apex of the passage from one downstream section to the other. In addition, successful implementation of this alternative would require the fish to change their migratory behavior as they would need to swim downstream as part of their upstream migration.

Table 4-9. Screening of Alternative 10: Fish Bypass: Bogus Creek Bypass Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not remove any of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not enable fish to pass without external assistance	Does not meet consideration
Advance restoration of salmonids	Would not likely be used by fish as a passage facility	Does not meet consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality with dams still in place	Does not meet consideration
Technically feasible	Would not be effective	Does not meet consideration

The CDFG studied the effectiveness of a predecessor to this alternative and presented its findings in a technical memorandum in 2009. CDFG found that in order for Chinook salmon to be able to use this alternative for fish passage, the stream depths and flows of Cold Creek would have to be greater than the flows included in this alternative. CDFG also determined that behavioral traits of anadromous fish would prevent them from using the fish bypass rather than the Klamath River due to their lack of familiarity with these creeks. Although Alternative 10 has been updated from the alternative assessed in the 2009 study, these findings remain applicable to Alternative 10.

Because the KHSA and KBRA would not move forward, several of the programs under the KBRA would not be implemented to provide reliable water or power supplies.

This alternative **will not be retained for more detailed analysis in the EIS/EIR** because it does not meet any elements of the purpose and need under NEPA or program objectives under CEQA.

4.2.11 Alternative 11 – Fish Bypass: Alternate Tunnel Route

Alternative 11 would be similar to Alternative 10 except that the main fish passage would be a tunnel. The alternative would not include implementation of the KHSA or KBRA. Table 4-10 summarizes the evaluation of the Fish Bypass: Alternate Tunnel Route according to the screening considerations.

Table 4-10. Screening of Alternative 11: Fish Bypass: Alternate Tunnel Route Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not remove any of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not likely be used by fish	Does not meet consideration
Advance restoration of salmonids	Would not enable fish to pass without external assistance	Does not meet consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality with dams still in place	Does not meet consideration
Technically feasible	Would not be effective	Does not meet consideration

The Fish Bypass: Alternate Tunnel Route Alternative would not meet any of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for the full volitional passage of fish. Because the KHSA and KBRA requirements would not be met, the programs under the KBRA would not be implemented to provide reliable water or power supplies.

Although the 2009 CDFG technical memorandum (See Section 4.2.10) did not address this particular alternative, many of the concerns noted therein would be applicable to this alternative as well. Use of the tunnel might address concerns about flows on Cold Creek and the multi-directional migration corridor; however, fish would still be unlikely to choose this new migration route rather than the mainstem of the Klamath River.

This alternative **will not be carried forward for more detailed analysis in the EIS/EIR** because it does not meet any elements of the purpose and need under NEPA or program objectives under CEQA.

4.2.12 Alternative 12 – Notching Four Dams

Alternative 12 would involve implementation of the KHSA as described in the agreement, and would include full implementation of the KBRA and its component elements. Because the alternative is consistent with the objectives of these agreements, Alternative 12 would fully meet the elements of the purpose and need/project objectives. Table 4-11 summarizes the evaluation of the Notching Four Dams Alternative according to the screening considerations.

Table 4-11. Screening of Alternative 12: Notching Four Dams Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would meet requirements of both agreements	Meets consideration
Free-flowing condition	Would allow a free-flowing river condition	Meets consideration
Full volitional passage of fish	Would remove portions of dams blocking river to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed and include restoration actions in KBRA to advance restoration	Meets consideration
Reliable water supplies	Would establish diversion patterns based on year types in the KBRA to improve reliability of water supplies	Meets consideration
Reliable power supplies	Would implement power program to ensure reliable electricity at affordable rates	Meets consideration
Improve long-term water quality	Would create a free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

The Notching Four Dams Alternative meets all of the screening considerations. Implementation of this alternative would require long-term maintenance of retained appurtenant structures. Deconstructing the dams would release the sediment stored behind the dams into the river downstream, which could temporarily affect water quality and aquatic species in the river. In order to create a free-flowing river, the four dams would have to be notched in a manner similar to that used for Partial Facilities Removal in Alternative 3. This alternative is very similar to Alternative 3, and would result in the same type of effects as Alternative 3. Therefore, this alternative **will not be carried forward for more detailed analysis in the EIS/EIR as a separate alternative**.

4.2.13 Alternative 13 – Federal Takeover

Alternative 13 would include a federal takeover of the Four Facilities for removal and would not include implementation of the KHSA or the KBRA. Table 4-12 summarizes the evaluation of the Federal Takeover Alternative according to the screening considerations.

The Federal Takeover Alternative would not meet all of the screening considerations. Implementation of this alternative would result in a free-flowing river and provide for the full volitional passage of fish, and would therefore advance salmonid restoration, but because the KHSA and KBRA requirements would not be not met, the programs under the KBRA would not be implemented to provide reliable water or power supplies. The schedule for dam removal would be similar to the current schedule under the KHSA.

This alternative **will not be carried forward for more detailed analysis in the EIS/EIR** because the environmental effects would be generally the same as those under Alternative 2 (and have generally the same timeframe). This alternative would not reduce or lessen significant environmental effects. Moreover, the federal government has not expressed an interest in taking over the facilities.

Table 4-12. Screening of Alternative 13: Federal Takeover Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not fully implement the KHSA	Does not meet consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would create a free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

4.2.14 Alternative 14 – Full Removal of Five Dams

Alternative 14 would involve removal of Keno Dam in addition to the Four Facilities that would be removed under Alternative 2. Table 4-13 summarizes the evaluation of the Full Removal of Five Dams Alternative according to the screening considerations.

Table 4-13. Screening of Alternative 14: Full Removal of Five Dams Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not meet the KHSA requirements because of the removal of Keno Dam	Does not meet consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed and include restoration actions in KBRA to advance restoration	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would create a free-flowing river, increase inflow, and implement restoration actions that improve water quality	Meets consideration
Technically feasible	Would be technically feasible	Meets consideration

The Full Removal of Five Dams would not meet all of the screening considerations. Implementation of this alternative would result in a free-flowing river and provide for the full volitional passage of fish, and therefore would advance salmonid restoration. However, the programs under the KBRA would not be implemented to provide reliable water or power supplies because the alternative would not include the KHSA or the connected elements of the KBRA. Implementation of this alternative would require construction to maintain and continue current water diversions. It is unknown whether newly constructed facilities to deliver water would be able to fully provide for legal uses of water associated with Keno Dam.

Alternative 14 **will not be carried forward for more detailed analysis in the EIS/EIR** because it does not fully meet the purpose and need under NEPA or the project objectives under CEQA (because it is not consistent with the KHSA) and it would not avoid or lessen potential significant environmental effects of the Proposed Action. Implementation of this alternative would require substantial construction to continue current water diversions, which would likely create environmental and social effects that would be greater than the effects associated with other alternatives that are being carried forward.

4.2.15 Alternative 15 – Full Removal of Six Dams

Alternative 15 would involve removal of the Keno and Link River Dams in addition to the four dams that would be removed under Alternative 2. Table 4-14 summarizes the evaluation of the Full Removal of Six Dams Alternative according to the screening considerations.

Table 4-14. Screening of Alternative 15: Full Removal of Six Dams Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not meet the KHSA requirements because of the removal of Keno and Link River Dams	Does not meet consideration
Free-flowing condition	Would remove dams to allow the river to flow freely	Meets consideration
Full volitional passage of fish	Would remove dams to provide for full volitional fish passage	Meets consideration
Advance restoration of salmonids	Would provide access to more of the watershed and include restoration actions in KBRA to advance restoration	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Unknown whether action would improve long-term water quality	Needs more information
Technically feasible	Would be technically feasible	Meets consideration

The Full Removal of Six Dams would not meet all of the screening considerations. Implementation of this alternative would result in a free-flowing river and would provide for the full volitional passage of fish, and therefore would advance salmonid restoration. Some of the programs under the KBRA would not be implemented to provide reliable water or power supplies because the KHSA and the connected elements of the KBRA would not be part of this alternative. Link River Dam regulates Klamath River flow and Upper Klamath Lake levels, and Link River Dam's effect on water quality in the river and the lake has not been analyzed.

The alternative would not be consistent with the tribal trust water rights associated with Upper Klamath Lake. In addition, the removal of Link River Dam would not meet legal requirements of Reclamation's Klamath Project. Further, Link River Dam is used to regulate water levels for the ESA-listed Lost River and shortnose suckers, and removal of the facility could affect these fish.

Alternative 15 **will not be carried forward for more detailed analysis in the EIS/EIR** because it does not fully meet the purpose and need under NEPA and project objectives under CEQA (because it is not consistent with the KHSA) and it would not avoid or lessen significant environmental effects of the Proposed Action. Implementation of Alternative 15 would also not be likely to meet ESA requirements or tribal trust water rights within Upper Klamath Lake.

4.2.16 Alternative 16 – Dredge Upper Klamath Lake

Alternative 16 would include dredging to improve water quality and storage at Upper Klamath Lake. Table 4-15 summarizes the evaluation of the Dredge Upper Klamath Lake Alternative according to the screening considerations.

Table 4-15. Screening of Alternative 16: Dredge Upper Klamath Lake Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not meet the KHSA requirements	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not provide for volitional fish passage	Does not meet consideration
Advance restoration of salmonids	Uncertain whether action would advance salmonid restoration	Needs more information
Reliable water supplies	Would provide increased water storage	Meets consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Unknown whether action would improve long-term water quality	Needs more information
Technically feasible	Would be technically feasible	Meets consideration

Dredging Upper Klamath Lake would not meet most of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for the full volitional passage of fish. Because the KHSA and the connected elements of the KBRA would not be part of this alternative, many of the programs under the KBRA would not be implemented to provide reliable water or power supplies.

Alternative 16 **will not be carried forward for more detailed analysis in the EIS/EIR** because it would not meet the NEPA purpose and need or most of the CEQA objectives.

4.2.17 Alternative 17 – Predator Control

Alternative 17 would promote fish recovery by reducing predation on salmonids by birds and marine animals. As an alternative to the Proposed Action, Alternative 17 would not include implementation of the KHSA or KBRA and its component elements. Table 4-16 summarizes the evaluation of the Predator Control Alternative according to the screening considerations.

Table 4-16. Screening of Alternative 17: Predator Control Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not meet the KHSA requirements	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not provide for volitional fish passage	Does not meet consideration
Advance restoration of salmonids	Could decrease predation at mouth of river, allowing more fish to pass	Meets consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality with dams still in place	Does not meet consideration
Technically feasible	Would be technically feasible	Meets consideration

Predator Control would not meet most of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for the full volitional passage of fish. This alternative's actions could advance restoration of salmonids; therefore, it satisfies that screening consideration. However, reducing predation of salmonids at the mouth of the Klamath River would address only one factor that could affect fish and would not improve any of the upstream conditions for anadromous fish. Because the alternative would not include the KHSA or the connected elements of the KBRA, several of the programs under the KBRA would not be implemented to provide reliable water or power supplies.

Alternative 17 **will not be carried forward for more detailed analysis in the EIS/EIR** because it would not meet the purpose and need under NEPA or objectives under CEQA. Moreover, it would be difficult to permit because of biological concerns.

4.2.18 Alternative 18 – Partition Upper Klamath Lake

Alternative 18 would include creation of a partition in Upper Klamath Lake to increase the water storage within the lake. Table 4-17 summarizes the evaluation of the Partition Upper Klamath Lake Alternative according to the screening considerations.

Table 4-17. Screening of Alternative 18: Partition Upper Klamath Lake Alternative

Consideration	Influencing Factors	Rating
Consistent with KBRA and KHSA	Would not remove any of the four dams	Does not meet consideration
Free-flowing condition	Would not allow a free-flowing river condition	Does not meet consideration
Full volitional passage of fish	Would not provide for full volitional fish passage	Does not meet consideration
Advance restoration of salmonids	Would not advance of salmonid recovery	Does not meet consideration
Reliable water supplies	Would not implement water supply provisions of the KBRA	Does not meet consideration
Reliable power supplies	Would not implement power supply provisions of the KBRA to provide reliable electricity at affordable rates	Does not meet consideration
Improve long-term water quality	Would not improve water quality with dams still in place	Does not meet consideration
Technically feasible	Would be technically feasible	Meets consideration

Partitioning Upper Klamath Lake would not meet most of the screening considerations. Implementation of this alternative would not result in a free-flowing river or provide for volitional fish passage and would not advance the restoration of salmonids. Although water storage would be increased by the partition, this increase would not be sufficient to provide for reliable water supplies throughout the basin. Because the alternative would not include the KHSA or the connected elements of the KBRA, several of the programs under the KBRA would not be implemented to provide reliable water or power supplies. One objective of the partition would be to concentrate higher quality water in a smaller area of Upper Klamath Lake, which could improve water quality conditions in downstream reaches of the river. These changes would, however, be small and would be insufficient to ameliorate adverse water quality conditions downstream of Upper Klamath Lake.

Alternative 18 **will not be carried forward for more detailed analysis in the EIS/EIR** because it would not meet the purpose and need under NEPA or objectives under CEQA.

4.3 Screening Results

Figure 4-1 shows the results of the alternatives screening process.

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Figure 4-1. Screening Consideration Matrix

Chapter 5
Alternatives Retained for Analysis

5.1 Alternative 2 – Proposed Action: Full Facilities Removal of Four Dams

5.1.1 Features of the Proposed Action

The Full Facilities Removal of Four Dams (Proposed Action) alternative is the removal of the Four Facilities (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) during a 12-month period as described in the KHSA. The alternative would include the complete removal of power generation facilities, water intake structures, canals, pipelines, ancillary buildings and dam foundations. These four dams and their appurtenant facilities are referred to herein as the Four Facilities. Preparation for dam removal would begin in May 2019 for Iron Gate Dam and June 2019 for Copco 1 Dam. Deconstruction efforts for the J.C. Boyle and Copco 2 facilities would commence after January 1, 2020 and all four dams would be completely removed by December 31, 2020.

DOI has developed preliminary concepts for how each facility would be removed based on PacifiCorp's detailed engineering drawings and current conditions. Members of the DOI engineering team have inspected each dam site to confirm the specifics of project features that form the basis for alternative design. In general, this alternative would include removal of all facilities and sealing or securing of areas made unsafe by dam removal activities. The KHSA states that a DRE would remove the facilities, and that the implementing agencies would select the DRE as part of KHSA implementation. The following descriptions provide more detail on full facility removal at each dam site.

5.1.1.1 J.C. Boyle Dam and Powerhouse

The J.C. Boyle Development consists of a reservoir, combination embankment and concrete dam, spillway with Tainter gates, diversion water intake structure, water conveyance system, and powerhouse on the Klamath River between RM 228 and RM 220. The dam has a concrete spillway section with flow control gates and an earth embankment section to retain water. The embankment dam is 68 feet high above the original riverbed, 15 feet wide at its crest, and has a length of 413 feet. The reservoir side of the embankment dam has a rise of 1 vertical foot for every 3 horizontal feet, referred to as a 3H:1V slope. A 3-foot-thick layer of riprap protects the upstream slope. The downstream slope is constant at 2.5H:1V with a 16-foot-wide berm for an access road. Below the access road, a 2-foot -thick layer of riprap protects the slope. J.C. Boyle

Dam impounds a narrow reservoir (J.C. Boyle Reservoir) with a surface area of 420 acres and a storage capacity of approximately 2,629 acre-feet of at river water surface elevation 3,793.5 feet.

Diverted water is conveyed a total distance of 2.56 miles through a steel pipe, concrete canal (2 miles), tunnel, and penstock pipe to the powerhouse. The powerhouse is on the right bank approximately 4.3 river miles downstream from the dam, as illustrated in Figure 5-1. The powerhouse is an outdoor-type structure with two vertical shafts and Francis generating units, with a total rated capacity of about 98 megawatts (MW).

Figure 5-1. J.C. Boyle Dam, Reservoir, and Powerhouse

Full removal of the J.C. Boyle Dam and Powerhouse would include removal of the entire embankment dam, concrete spillway and Tainter gates, and concrete fish ladder. This alternative would also include removal of ancillary facilities, such as the power water intake structure, left[4] abutment concrete gravity section, steel conveyance pipeline and pipeline support structure that crosses the river, and the concrete conveyance canal. The extensive headcut downstream of the

[4] River left and right refer to the left and right banks of the river as one faces downstream.

forebay overflow discharge canal would be filled and stabilized with a portion of the material removed from the dam structure.

Under this alternative, the DRE would remove not only the immediate facilities at the dam, but also the powerhouse, powerhouse crane, turbines, concrete structures, and power generation support equipment. The DRE would remove the tunnel entrance structure and seal the tunnel at both ends to prevent entry. Further, the DRE would fill the tailrace area of the powerhouse to restore natural river conditions in this area. The DRE would perform a controlled reservoir drawdown to access the dam for deconstruction using the spillway gates, conveyance pipeline and canal, and diversion conduit.

Trapped sediments in the reservoir consist primarily of highly erodible silts and clays. DOI's modeling studies (DOI 2011) indicate that drawdown would erode and flush 41 to 65 percent of the stored sediment downstream. Once eroded from the reservoir, the fine sediment would continue in suspension to the ocean. Large quantities of sediment would remain in place after dam removal, primarily on terraces above the active channel. Restoration of these areas following drawdown would minimize erosion; restoration would include seeding with herbaceous species and planting with woody species in accordance with reservoir restoration plans (DOI 2011).

Figure 5-2. Copco 1 Dam showing gated spillway and penstock pipes

5.1.1.2 Copco 1 Dam and Powerhouse

Copco 1 Dam (Figure 5-2) is in a bedrock canyon on the Klamath River at RM 198.6. The Copco 1 Dam is a concrete, gravity arch dam with a spillway crest approximately 115 feet above the original riverbed, with concrete cutoff walls that extend an additional 100 feet below the existing river bed elevation. The overall dam structure height is 215 feet from the spillway crest to the lowest depth of excavation at the base of the dam foundation. The crest length between the rock abutments is about 410 feet, and the deck is 8 feet wide. The upstream face of the dam is vertical at the top and the downstream face is stepped with risers that are generally 6 feet high. The width of the dam at the historical river level is approximately 94 feet.

Construction records show that the dam includes 465 tons of 30-pound steel rails for reinforcement. Vertical rails are on the upstream side in rows parallel to the face, 4.5 feet apart. Spacing of horizontal mats of rails varied from 5 to 8 feet. Dam construction methods included the placement of small amounts of concrete at a time with the rails projecting out of the sides to connect the adjacent concrete sections. An ogee-type spillway is on the crest of the gravity arch dam. It has 13 bays controlled by 14 foot by 14 foot Tainter gates. Figure 5-2 shows these Tainter gates, the gated spillway, and penstock pipes.

Copco 1 Powerhouse is on the river right bank of the Klamath River, immediately downstream from the dam. It is a conventional, indoor type structure with two horizontal, double runner, Francis turbines that drive 10 MW generators.

Under the Proposed Action, the DRE would remove the entire concrete gravity arch dam from canyon wall to canyon wall and five feet below the existing streambed (a total of 130 feet from the top of the dam). Removing the entire facility would entail removal of the concrete water intake structure, concrete gate houses, penstock pipes and supports, powerhouse, and power generation support facilities. The water intake facility on the left side of the dam would be removed and the associated tunnel would be plugged to prevent unauthorized entry.

This alternative would also include removal of the switchyard (above the dam on the right abutment) and any unused transmission lines, including fencing, poles, and transformers. Removal of the Copco 1 switchyard would include all transformers, breakers, switches, and take-off structures. Removal would include the steel penstocks: two 10-foot-diameter (reducing to two 8-foot-diameter) pipes and one 14-foot-diameter pipe (reducing to two 8-foot-diameter pipes) from the intake structure to the powerhouse, including three vertical air vent pipes.

Using the spillway gates and modified diversion tunnel, the DRE would perform a controlled reservoir drawdown to access the dam for deconstruction. DOI’s modeling indicates that the initial drawdown would flush 46 to 81 percent of the silts and clays behind the dam. Once eroded from the reservoir, the fine sediment would continue in suspension all the way to the ocean. After drawdown, the remaining sediments would consolidate and decrease in thickness. Copco 1 Reservoir sediments would likely experience a substantial amount of consolidation, which would decrease the depth of the remaining sediment. Initial DOI modeling studies show change in sediment depth layers up to 61 percent of original depth due to desiccation (DOI 2011). Similar shrinkage of sediment layers would be expected for J.C. Boyle and Iron Gate Reservoirs. Restoration efforts would minimize future erosion and sedimentation through planting of herbaceous and woody species and eventually, natural flora colonization would occur.

5.1.1.3 Copco 2 Dam and Powerhouse

Copco 2 Dam is in a confined canyon on the Klamath River at RM 198.3. Copco 2 Dam is a concrete, gravity dam with an earthen embankment section, gated spillway with Tainter gates, water conveyance system, and powerhouse. Figure 5-3 shows the existing dam with gated concrete spillway. The dam has a gated intake to a water conveyance tunnel on the left abutment, a central spillway section that is 145 feet long, with five 26 foot by 11 foot radial Tainter gates, and a 132 foot long earthen embankment with cutoff wall on the right abutment. The dam is 33 feet high, with an overall crest length of 335 feet and a crest width of 9 feet. A corrugated metal pipe with a capacity of 5 cfs flows to the Bypass Reach downstream of the dam.

Copco 2 Powerhouse is 1.5 miles downstream of Copco 2 Dam, on the left bank of the river. Water flows from the dam through 2,440 feet of concrete-lined tunnel, 1,313 feet of wood-stave pipeline, an additional 1,110 feet of concrete-lined tunnel, an underground surge tank (including an air vent and overflow spillway), and two steel penstocks. The diameter of the tunnel and wood-stave pipeline sections is 16 feet. The two penstocks, one 405 feet long and one 410 feet long, range from 16 feet in diameter at the upstream ends to 8 feet in diameter at the turbine spiral cases. A 138 inch butterfly valve near the downstream end of each penstock can shut off flow.

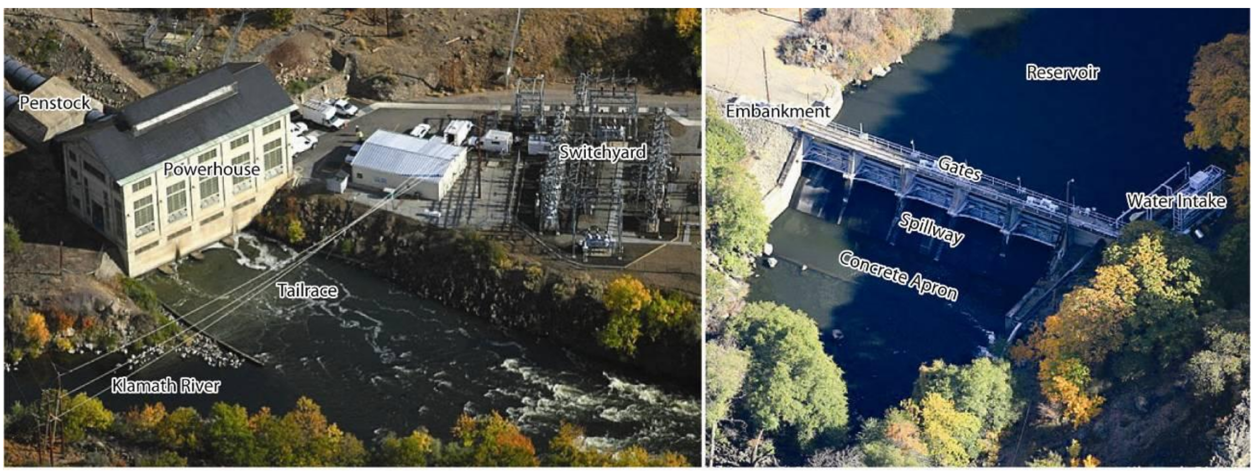

Figure 5-3. View of Copco 2 Powerhouse (left photo) and Dam

The Copco 2 Powerhouse is a reinforced-concrete structure with two vertical, Francis turbines. There are three outdoor, single-phase V transformers for each generator to step up the voltage and also three outdoor, single-phase V step-up transformers for interconnection to the transmission system. A 69 kV transmission line (PacifiCorp Line No. 15) is 1.2 miles long and connects the Copco 2 Powerhouse to the Copco 1 switchyard. A second 69 kV transmission line (also Line No. 15) is 0.14 miles long and connects the Copco 2 Powerhouse to the Copco 2 switchyard.

Full removal of the dam and diversion intake would include removal of the concrete spillway and Tainter gates, spillway apron and sill, concrete sidewalls, water intake structure, and reshaping of the embankment on river right to form a natural channel. Under this alternative, the DRE would remove the creosote treated wood-stave penstock portion between the first and second tunnels, and would haul the removed material to a disposal facility about 120 miles away. This alternative would include removal of the steel penstocks between the second tunnel and the powerhouse and plugging of all remaining open tunnel and shaft portals with concrete to avoid unauthorized entry.

This alternative would also include removal of Copco 2 Powerhouse, along with the power generation equipment (turbines and piping), and unused transmission lines, piles and transformers. Restoration would include backfill of the excavated tailrace channel between the powerhouse and the river to restore natural river conditions. The Copco 2 substation at the powerhouse, and a 230 kV switchyard on a bluff north of the river, would remain in service following dam removal.

5.1.1.4 Iron Gate Dam and Powerhouse

The Iron Gate Dam and Powerhouse are at RM 190.1 on the Klamath River in a confined bedrock canyon. Iron Gate Dam is a zoned earthfill embankment with a height of approximately 194 feet from the rock foundation at the base of the dam to the dam crest (Figure 5-4). The dam crest width is 20 feet and its length spanning the valley is 740 feet. The dam has a central, vertical, asymmetrical clay core, supported by upstream and downstream shells of pervious rockfill with a maximum rock size of 12 inches. The upstream embankment slope is 3H:1V at the base, increasing to 2.5H:1V in the upper portion of the slope. In 2003, installation of a cantilevered sheet pile raised the water-retaining height in the reservoir but did not raise the overall dam elevation, resulting in a sheet pile parapet wall that is 5 feet high, shown in Figure 5-4. A 10-foot layer of riprap protects the upstream slope, and a 5-foot layer of riprap protects the downstream slope.

Figure 5-4. Iron Gate Dam (left photo) power generating facilities (left photo) and dam crest and parapet sheet pile wall (right photo)

The earthfill embankment has a drainage system with a near-vertical chimney drain and clean, free-draining material between the core and the downstream shell, which connects to a horizontal blanket drain laid over the foundation. The blanket drain contains a 30 inch diameter concrete pipe drain and outlet at a manhole at the toe of the dam. Two graded filter zones are between the core and the chimney drain to prevent the migration of fine material from the core into the downstream shell or blanket drain. A filter over the top of the horizontal blanket drain protects it from the migration of fine material into the overlying downstream shell. Another filter is between the core and the upstream shell. The dam sits on sound basalt bedrock. The powerhouse is immediately downstream of the dam on the left bank of the river.

Full removal of the dam and powerhouse would include removal of the earthen embankment dam, diversion tunnel gate structure, concrete water intake structure, powerhouse generation facility, penstock and its concrete supports, unused transmission lines, and the switchyard. The DRE would bury the concrete spillway side-channel inlet structure, chute, and terminal structure (requiring up to 300,000 yd^3 of backfill) to restore the pre-dam appearance of the right abutment bedrock canyon. The diversion tunnel portals would be plugged with concrete to avoid unauthorized entry. Restoration would include backfill of the excavated tailrace channel between the powerhouse and the river.

This alternative would include removal of the fish handling facilities at the base of the dam, but the Iron Gate Fish Hatchery would remain in place. PacifiCorp would need to secure an alternate water source for the hatchery. The existing 30 inch diameter, cold water supply pipe from the penstock intake structure to the fish hatchery would be removed with the embankment dam. PacifiCorp would fund eight years of hatchery operations after decommissioning of Iron Gate Dam, after which the parties will be responsible for identifying funding for continued operations.

The DRE would draw down the reservoir to access the dam for deconstruction and facilities removal using the penstock bypass and modified diversion tunnel. DOI modeling indicates that this drawdown would flush 25 to 38 percent of the trapped sediments in the reservoir (primarily silts and clays). Once eroded from the reservoir, the fine sediment would continue in suspension all the way to the ocean. The remaining sediments would consolidate after drawdown, and restoration efforts would stabilize the remaining sediment.

5.1.2 Schedule for the Proposed Action

The DRE and PacifiCorp would need to agree on a final schedule for halting power generation and starting reservoir drawdown as described in the KHSA. The DRE would begin preparatory work in May 2019. The initial schedule for this alternative shows power generation at the Iron Gate and J.C. Boyle projects stopping on December 31, 2019. Power generation would stop at Copco 2 Powerhouse in April 2020 and Copco 1 would cease in October 2019. The following sections describe the proposed operations and drawdown plans for each reservoir. Figure 5-5 provides a schedule for the Proposed Action based on construction requirements for removal.

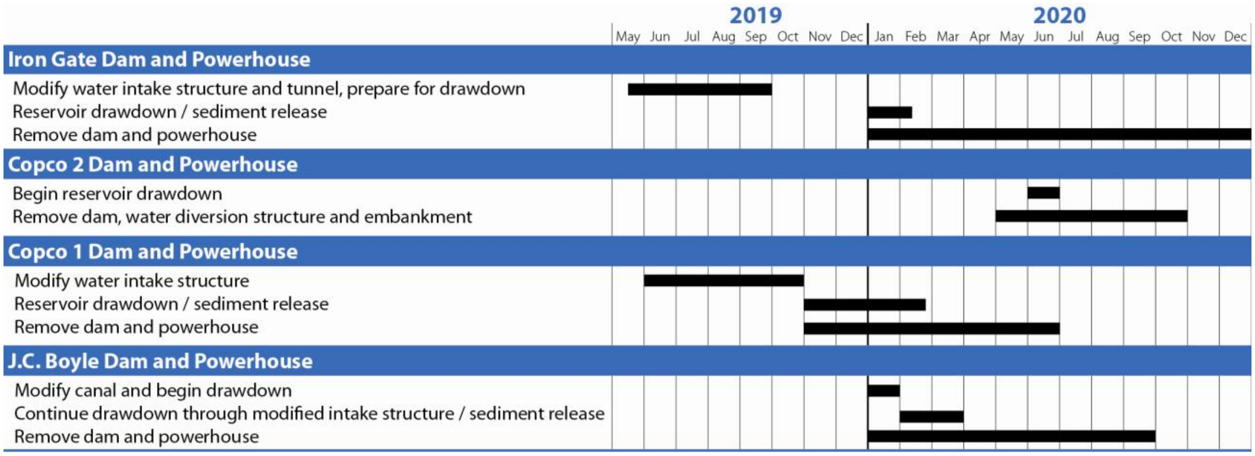

Figure 5-5. Anticipated Schedule for Full Facilities Removal of Four Dams

For removal of J.C. Boyle Dam, only sediment stored in the J.C. Boyle Reservoir would pass through because the alternative does not involve alterations of reservoirs upstream from the project site. The Boyle Reservoir does not have structures around the reservoir rim that could be damaged by slope failures, so embankment slope stability and associated safety issues would control the drawdown rate. A drawdown rate of 1 foot per day would not cause a rapid drawdown failure, because the embankment shells are a mixture of sand and gravel that should have a high strength. A drawdown rate of more than 1 foot per day would most likely be acceptable for the lower portion of the reservoir—during the later part of the drawdown period, when there may be limited control of reservoir releases. The streamflow diversion plan could result in rapid drawdown of approximately 10 feet (between elevations 3,780 and 3,770) and 8 feet (between elevations 3,770 and 3,762) in less than 24 hours, but each of these rapid drawdowns would be followed by a sustained hold period of more than one week before any further drawdown. J.C. Boyle Dam removal would happen primarily in May, June, and July 2020.

The schedule for the Proposed Action Copco 1 plan assumes that power generation at Copco 1 Powerhouse would cease on October 31, 2019. Reservoir drawdown would start at that time at an average drawdown rate of 6 feet per week. The drawdown rate is limited to 1 foot per day for the upper 50 feet of the reservoir and 3 feet per day below that resulting from notching the dam. January through June 2020 would be the primary dam removal period.

The Proposed Action would include power generation at Copco 2 Powerhouse for up to five months after the January 1, 2020 date in the KHSA. Reservoir drawdown at Copco 2 Dam would not commence until June 2020. Because there is no sediment stored at Copco 2 Dam and the Copco 2 Reservoir slopes are stable, no drawdown rate limitations would apply to the removal of Copco 2 Dam. Sediment from upstream dam removals would flow through this area and would not be stored in the Copco 2 Reservoir. The DRE could maintain minimum releases of 5 to 10 cfs to the downstream Bypass Reach if necessary without significant impacts on the demolition activities. The upstream reservoirs at J.C. Boyle and Copco 1 Dams would have already been mostly drained by the time removal work would begin at Copco 2 Dam, and should not affect the streamflow at the Copco 2 Dam site. May through September 2020 would be the primary dam removal period.

Under the Proposed action, power generation at Iron Gate Dam would end on December 31, 2019. Reservoir drawdown would start on January 1, 2020. An average drawdown rate of 1.7 feet per day, with a maximum rate of 10 feet per day, would ensure stability of Iron Gate Dam because the dam has a wide, pervious outer zone that has high strength and should drain relatively quickly as the reservoir is drawn down. The DRE would perform primary dam removal throughout 2020.

5.1.3 Operations and Adaptive Management of the Proposed Action

PacifiCorp would continue to operate the facilities for the benefit of customers and retain all rights to the power from the facilities until each of the facilities are decommissioned in accordance with the KHSA.

In order to effectively manage the drawdown phase of the Proposed Action, the DRE would develop a monitoring plan prior to implementation. Monitoring suspended sediment and downstream water quality conditions would allow for adaptive management opportunities during dam removal. Adaptive management would allow the DRE to address any unanticipated differences between predictive studies of sediment transport and the actual water quality during the dam removal period.

5.1.4 Construction Details of the Proposed Action

The following sections describe construction techniques and equipment for dam removal at each of the project sites.

5.1.4.1 J.C. Boyle Dam and Powerhouse

The DRE would take the following actions at J.C. Boyle Dam:

- Remove the spillway gates and traveling hoists using a large crane, with the reservoir drawn down below the spillway crest.
- Remove the reinforced concrete spillway bridge deck and piers in pieces using hydraulic excavators, or in sections using diamond-wire sawcutting.
- Remove the upstream concrete bulkheads for the diversion culvert one at a time with a crane or by blasting for additional reservoir drawdown.
- Remove the lower portion of the concrete spillway section in segments by hoe-ramming or by drilling and blasting, working behind a temporary cofferdam if necessary (left side first, with flows through a diversion culvert).
- Remove the reinforced concrete in deck, wall, and floor slabs in remaining features (including fish ladder, intake structure, power canal, forebay structures, powerhouse) using mechanical methods (e.g., hydraulic shears or hoe-ramming), or possibly in sections by diamond-wire sawcutting.

- Stockpile some rockfill for later use protecting slopes for the upstream cofferdam.
- Haul concrete rubble, mechanical and electrical equipment, and miscellaneous items in trucks to designated disposal sites as described below. All material that can be reused or recycled would be transported to an appropriate recycling location or transfer facility.

Dam removal would begin by drawing down the reservoir below the concrete spillway crest by using the penstock and diversion culvert at the bottom of the spillway. With the reservoir drawn down, the DRE would excavate the embankment dam by removing the earth fill from the top of the embankment and working downward with standard excavation equipment. The DRE would place portions of the excavated rockfill on the face of the isolation cofferdam upstream of the embankment. After embankment removal, the DRE would perform a controlled breach of the cofferdam. Natural erosion of the armored cofferdam would complete final reservoir drawdown. The DRE would fully isolate and remove the concrete spillway and fish ladder in dry conditions except the base of the spillway.

Estimated waste quantities for Full Facilities Removal at J.C. Boyle Dam and Powerhouse include 40,000 yd^3 of concrete, 140,000 yd^3 of earthfill, and 3,000 tons of mechanical and electrical items at the dam.

The DRE would use the original borrow pits on the right abutment of J.C. Boyle Dam for waste areas. The DRE would haul materials on existing unpaved roads to the disposal sites along the cleared transmission line corridor, and place some material within ravines below the transmission lines. The existing haul roads would require some initial clearing and minor improvements. The work below the high voltage transmission lines would require special precautions to maintain a safe work site. These precautions could include coordination with PacifiCorp and fencing off areas to ensure that structural features are avoided. The DRE would grade and slope disposal sites for drainage upon completion.

The DRE would place surplus waste concrete and earth materials into the eroded scour hole on the hillside below the forebay overflow spillway structure, to restore the area to near pre-dam conditions. The DRE would separate reinforcing steel from the concrete and haul the steel to a recycling facility in Klamath Falls, Oregon. The DRE would also haul mechanical and electrical equipment to Klamath Falls to be transferred to a suitable recycling facility outside the project boundaries. Potential hazardous materials, which would need specialized abatement and disposal requirements, include asbestos, batteries, bearing and hydraulic control system oils, polychlorinated biphenyls (PCBs), and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock pipes, surge tank, bulkhead gate, and generator gantry crane.

Construction activities at J.C. Boyle Dam and Powerhouse would require an estimated average workforce of 25 to 30 people for approximately 10 months. Attachment A includes equipment needed for the removal of J.C. Boyle Dam and Powerhouse and for restoration of the reservoir area.

5.1.4.2 Copco 1 Dam and Powerhouse

The DRE would take the following actions at Copco 1 Dam:

- Remove the spillway gates and traveling hoists using a large crane, with the reservoir drawn down below the spillway crest.
- Remove the reinforced concrete spillway bridge deck and piers in pieces using hydraulic excavators, or in sections using diamond-wire sawcutting.
- Remove the concrete gravity arch dam in 8-foot horizontal lifts using conventional drilling and blasting techniques. Dam removal would be challenging because the dam has large (cyclopean) boulders in the concrete matrix, and is reinforced with steel rails.
- Remove debris after blasting (concrete rubble and reinforcing steel) using a large tower crane on the right abutment.

The concrete dam crest could safely accommodate overtopping flows during dam removal without concern for frequency floods and freeboard. The DRE would notch the dam by creating 20 foot wide alternating openings that are a minimum of 16 feet deep. Drawdown of the upper 50 feet of the reservoir would be at a rate of 1 foot per day and the remaining drawdown would be at a rate of 3 feet per day.

Once the DRE removed the concrete dam structure down to the water level, it would isolate one side of the dam with a gravel cofferdam. The DRE would remove the isolated portion of the dam to 5 feet below the existing riverbed and then divert the river into the removed portion. The DRE would then isolate the other side of the dam and remove it. The DRE would use mechanical means (e.g., hydraulic shears and hoe-ramming) to excavate the reinforced concrete in deck, wall, and floor slabs for remaining features (including powerhouse and diversion intake structure).

The estimated waste quantity for Full Facilities Removal at Copco 1 Dam is 62,000 yd^3 of concrete and 1,200 tons of mechanical and electrical items at the dam and powerhouse.

The DRE would bury concrete rubble on the right abutment within an on-site disposal area. The DRE would separate reinforcing steel from the concrete and haul it to a local recycling facility in Weed, California. The DRE would then grade and slope the disposal areas for drainage.

The DRE would haul mechanical and electrical equipment to Yreka, California for transfer to a salvage company or disposal outside the project boundaries. Potential hazardous materials, which would need specialized abatement and disposal requirements, include asbestos, batteries, bearing and hydraulic control system oils, PCBs, and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock and air vent pipes.

The concrete dam and powerhouse are in a steep, narrow canyon. The existing access roads would require significant upgrades to handle the hauling of excavated concrete and provide access for a large crawler-mounted crane. Crane access may also be available from the left abutment, using existing unpaved roads. All work at the Copco 1 development could be performed within the existing FERC project boundaries.

Construction activities would require an estimated average workforce of 30 to 35 people for approximately 12 months. Attachment A includes equipment needed for the removal of Copco 1 Dam and Powerhouse and for restoration of the reservoir area.

5.1.4.3 Copco 2 Dam and Powerhouse

The DRE would take the following actions at Copco 2 Dam:

- Remove the spillway gates and traveling hoists using a large crane, with the reservoir drawn down as much as possible.
- Remove the reinforced concrete spillway bridge deck in pieces using hydraulic excavators, or in sections using diamond-wire sawcutting.
- Remove the remainder of the spillway structure using conventional drilling and blasting methods as each portion is dewatered.
- Excavate the reinforced concrete in deck, wall, and floor slabs for remaining features (including intake structure, gravity structure, sidewalls, apron, and powerhouse) using mechanical methods (e.g., hydraulic shears or hoe-ramming).

Copco 2 Dam is a concrete dam in a confined canyon with poor access. The existing access roads would require significant upgrades to handle the hauling of the excavated concrete and provide access for a large crawler-mounted crane. The access bridge across the Klamath River downstream of the powerhouse could require improvements to handle the construction equipment loads.

Estimated waste quantities for Full Facilities Removal at Copco 2 Dam and Powerhouse include more than 12,000 yd^3 of concrete, 1,500 yd^3 of earthfill, and more than 2,000 tons of mechanical and electrical items at the dam.

The DRE would bury concrete rubble on the right abutment within an on-site disposal area. The DRE would handle and dispose of reinforcing steel, concrete, and mechanical and electrical equipment in the same manner as for the Copco 1 Dam removal. The list of potential hazardous materials, which would have specialized abatement and disposal requirements, is the same for the Copco 2 development as it is for the Copco 1 Development.

Construction activities would require an estimated average workforce of 25 to 30 people for approximately 7 months. Attachment A includes equipment needed for the removal of Copco 2 Dam and Powerhouse.

5.1.4.4 Iron Gate Dam and Powerhouse

The DRE would take the following actions at Iron Gate Dam:

- Remove the embankment on the narrow crest section using conventional earthmoving equipment.
- Remove riprap with conventional earthmoving equipment.

- Excavate reinforced concrete in the deck, wall, and floor slabs for remaining structures (including intake structures, fish handling facilities, and powerhouse) using mechanical methods (e.g., hydraulic shears or hoe-ramming).
- Remove any mass concrete using conventional drilling and blasting methods.
- Install prefabricated steel pipe bridge for Yreka water supply line at upper end of reservoir area and realign pipe for long term stability after dam removal.

At Iron Gate Dam, the DRE would begin excavation of the embankment on the very narrow crest section, which would affect initial production rates because of the confined work area. As the excavation worked from the top of the dam crest in a downward direction, the width of the excavation footprint would become wider and additional equipment could be added to the excavation equipment fleet. The DRE would remove the riprap as the embankment is excavated down. Existing haul roads would require improvements to handle two-way traffic of large construction equipment between the dam and the disposal site. The access bridge across the Klamath River downstream of the dam could also require improvements to handle the construction equipment loads.

Estimated waste quantities for full removal of Iron Gate Dam and powerhouse include 12,000 yd^3 of concrete, 1.1 million yd^3 of earthfill, and 1,000 tons of mechanical and electrical items at the dam and powerhouse. Removal would also generate waste from four buildings with a combined area of 2,300 square feet.

An original borrow site approximately 0.75 miles upstream from the dam on the left abutment would serve as a disposal site for excavated embankment materials. Another disposal site would be the existing concrete-lined side-channel spillway, chute, and flip-bucket terminal structure, which could accept up to 300,000 yd^3 of excavated embankment material. As the excavation descended, the DRE would need to construct ramps out of the canyon. The DRE would stockpile some rockfill for later use as slope protection for the upstream cofferdam.

The DRE would bury concrete rubble within an on-site disposal area. The DRE would handle and dispose of reinforcing steel, concrete, and mechanical and electrical equipment in the same manner as for the Copco 1 and Copco 2 sites. The list of potentially hazardous materials, which would have specialized abatement and disposal requirements, is the same for the Iron Gate development as it is for the Copco 1 and Copco 2 sites.

The City of Yreka's water supply pipeline passes under the upstream end of the Iron Gate Reservoir and would become exposed to high-velocity river flows after dam removal. Anticipated scour depths are on the order of 10 feet around the pipe so it is not practical to bury the pipe deeper since the likelihood of encountering bedrock is high. Therefore, the DRE would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river. The prefabricated steel pipe bridge would be wide enough to accommodate the pipeline and walkway on the deck. The pipeline bridge would likely be composed of three spans: a center span of 200 feet and two end spans of 100 feet. The spans would be supported on concrete piers. The new pipeline would be connected to the existing buried pipeline at each end of the bridge. In order to avoid a disruption to the city's water supply, the permissible outage period would be limited by the available storage tank capacity.

Construction activities would require an estimated average workforce of 35 to 40 people for approximately 18 months. Meeting the daily production rates would require multiple shifts of workers. Attachment A includes equipment needed for the removal of Iron Gate Dam and Powerhouse and for restoration of the reservoir area. Table 5-1 provides a workforce summary for deconstruction at the four dam sites. In addition to the average construction workforce, there would be 5 to 10 on-site construction management staff (e.g., inspectors, field engineers) at each site for the duration of the project.

Table 5-1. Estimated Construction Workforce for Proposed Action

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	25 to 30 people	10 months	40–45	Jul 2020–Sep 2020
Copco 1	30 to 35 people	12 months	50–55	Nov 2019–Apr 2020
Copco 2	25 to 30 people	7 months	35–40	May 2020–Aug 2020
Iron Gate	35 to 40 people	18 months	75–80	Jun 2020–Sep 2020

5.1.4.5 Work Area Isolation for Dam Removal

The DRE would need to control water and isolate the work area from flowing water and aquatic organisms throughout the duration of construction. Control mechanisms would be installed prior to starting work for each dam removal. The DRE could control water in most areas using gravity diversions; however, pumps would be required to dewater isolated ponding. Dewatering would require electric, gasoline, or diesel powered pumps, along with flexible hosing to convey water. Pumps would discharge water away from the river into upland areas to prevent discharge of fine sediments to waterways. Pumps would be screened to prevent entrainment of fish. Screens would be 1/8-inch mesh, placed at sufficient distance from the pump intake to prevent fish from impinging against (colliding into) the screens. Prior to pumping, the DRE would conduct a fish rescue, as described below, within the screened area isolating the pump.

The DRE would work in wet conditions in areas that cannot be dried. For in-water work, physical barriers would isolate the work area. Barriers would consist of bulk bags, which are fabric bags filled with sand or gravel that can be stacked as “bricks” to temporarily isolate work areas. Alternately, the DRE could use steel sheets or piles, concrete blocks, gravel berms, inflatable berms or plastic sheeting as physical barriers to isolate work areas. All barriers would be temporary, and would be removed after completing work.

A fish rescue would be conducted in all areas that cannot be drained in a manner that allows fish to volitionally depart the area. Prior to the beginning of construction, the DRE would contact USFWS, NOAA Fisheries Service, CDFG, and the Oregon Department of Fish and Wildlife to identify specific methods for the rescue and obtain permits. It is anticipated that fish rescue efforts would target only native species and that these species would be relocated to suitable habitat within the basin. After a work area has been isolated so organisms cannot enter, and prior to initiating construction work, the area would be drained to a workable depth (3 to 4 feet maximum depth). A fish rescue crew lead by a qualified biologist would then enter the area and collect all fish. The fish rescue would likely use seines and/or backpack mounted electrofishing equipment. Rescued fish would be handled carefully and kept in aerated coolers at an appropriate temperature until they are released. Once the fish rescue has been completed, construction activities would begin.

5.1.5 KBRA

The Full Facilities Removal of Four Dams Alternative includes implementation of the KBRA. The KBRA is composed of multiple elements including actions, plans and programs to restore and sustain natural fish production, establish reliable water and power supplies, support regional economies, and provide for the support and protection of Indian Trust Assets. The KBRA also includes provisions for local governments and tribes to address economic development needs; provide regulatory assurances that adverse impacts on communities would be minimized; and support tribal participation in fisheries programs. Programs under the KBRA are grouped under the Fisheries Program, the Water and Power Program, the County and Tribal Programs.

5.1.5.1 Fisheries Program

The Fisheries Program of the KBRA has three main goals:

A. Restore and maintain ecological functionality and connectivity to historic habitat.

B. Re-establish and maintain naturally sustainable and viable populations of fish to the full capacity of the restored habitats.

C. Provide for full participation in harvest opportunities.

The key elements of the KBRA related to fisheries include the following:

- An extensive habitat restoration program throughout the basin
- Fisheries reintroduction plans and programs
- Fisheries monitoring plans and programs
- Actions intended to increase flows and reliability of instream water in the main stem of the Klamath River and its tributaries (with the exception of the Trinity River basin)

Fisheries Restoration Plans

The Phase I Fisheries Restoration Plan is intended to establish restoration priorities and criteria for restoration project selection for the immediate future through 2020. The Phase I Plan is scheduled to be finalized by March 2012. Implementation of the plan may include actions for restoration of existing fisheries as well as actions in anticipation of reintroduction of anadromous fish upstream of Iron Gate Dam. Specific elements could include restoration and protection of riparian vegetation, water quality improvements, restoration of stream channel functions, measures to prevent excessive sediment inputs, remediation of fish passage blockages, and prevention of entrainment into diversions. Many of these activities are already on-going throughout the basin. However, the Phase I Fisheries Restoration Plan would prioritize activities and, with additional funding, would allow the realization of greater improvements.

Under Phase I implementation, the effectiveness of the restoration activities would be monitored under the Fisheries Monitoring Plan. Monitoring results would be used in the development of the Phase II Plan to adjust the recommended mix of restoration activities, priorities, and/or project locations to more effectively restore aquatic habitats. The Phase II Fisheries Restoration Plan would establish long-term restoration priorities and an adaptive management process to maintain fish restoration through 2060. The draft Phase II Plan is to be prepared 7 years after the Phase I Plan is finalized, and a final plan is to be completed by March 31, 2022.

Fisheries Reintroduction Plans

The States of California and Oregon would each prepare separate Fisheries Reintroduction plans if each state concurs with an affirmative Secretarial Determination. The Fisheries Reintroduction plans are intended to identify the facilities and actions that would be necessary to start reintroduction of anadromous fish upstream of Iron Gate Dam. Each state would monitor fish populations and might take actions, such as managing the fish harvest, to protect populations during implementation of their Phase I Fisheries Reintroduction Plan.

Reintroduction downstream of Upper Klamath Lake is to be a passive process and would be allowed to occur naturally with the restoration of a free-flowing condition following dam removal. Reintroduction activities outlined in the KBRA specifically exclude the Trinity River watershed upstream of its confluence with the Klamath River; Lost River and its tributaries; and Tule Lake basin. Reintroduction upstream of Upper Klamath Lake may be accomplished by more active means if necessary. Once self-sustaining populations are established, Phase II Fisheries Reintroduction plans would be developed that integrate anadromous fisheries into each state’s harvest management plans.

Fisheries Monitoring Plan

The Fisheries Monitoring Plan is intended to direct a cohesive effort to monitor the status and population trends of Chinook and coho salmon, steelhead trout, resident rainbow trout, lamprey, suckers, bull trout, sturgeon, and eulachon. In addition to monitoring fish populations, the monitoring plan calls for collection of data on environmental water, effectiveness of restoration activities, and factors that may limit recovery and restoration of fish populations. The Monitoring Plan is to be completed by March 2012. Implementation would start in the event of an affirmative determination by the Secretary. The results of the monitoring program are to be reviewed in 2020 and 2030 at a minimum.

Additional Water for Fish

There are many components of the KBRA that are intended to result in additional instream flows and to retain water in Upper Klamath Lake in order to support fisheries restoration. Most of these actions are intended to benefit both anadromous and sucker fish populations regardless of the effects of dam removal. Several programs to provide additional water for fish are identified in the KBRA:

- Diversion limitations to Reclamation's Klamath Project
- Interim program of water lease and purchase to reduce diversions upstream of Upper Klamath Lake
- Voluntary Water Use Retirement Program (WURP) in the Upper Basin to add up to 30,000 acre-feet of instream water per year to the Upper Klamath basin including Wood River, Sprague River, Sycan River (except Sycan Marsh), and Williamson River
- Increased water storage and conservation through specific projects:
  - Reconnect Barnes and Agency Lake Ranches to Agency Lake (project under study) – would add 63,700 acre-feet of potential storage capacity
  - Reconnect Wood River wetlands to Agency Lake (under study) – would add 16,000 acre-feet of potential storage capacity;
- Monitor groundwater use to ensure that river flows and springs are not adversely affected by diversions
- Assess the effects of climate change on basin water budget
- Acquisition of an additional 10,000 acre-feet of storage in the Upper Basin to allow increased diversions in some years, to mitigate effects of drought, and/or to further fish restoration goals.

Most of the programs that provide additional water for fish are described under the Water and Power Program section of the KBRA.

5.1.5.2 Water and Power Program

The Water and Power Program in the KBRA is intended to address water supply reliability and ensure affordable power for on- and off-Project agricultural users, and for moving water through Reclamation's Klamath Project.

The KBRA includes a number of planning efforts that, combined with the diversion limits and the WURP, are intended to meet these goals. Plans and programs to be developed and implemented under the Water and Power Program of the KBRA include these:

- Limitations on water diversions to Reclamation's Klamath Project users including the Klamath Basin National Wildlife Refuge System (KBRA Section 15)
- A WURP to allow for more instream water for fisheries (KBRA Section 16.2.2)
- Interim Flow and Lake Level Protection Plan (KBRA Section 20.4)
- On-Project Plan (KBRA Section 15.2)
- Winter Shortage Plan (KBRA Section 15.1.2.F)

- Off-Project Water Settlement (KBRA Section 16)
- Off-Project Reliance Program Plan (KBRA Section 19.5)
- Power for Water Management Plan (KBRA Section 17)
- Drought Plan (KBRA Section 19.2)
- Emergency Response Plan (KBRA Section 19.3)
- Climate Change Evaluation (KBRA Section 19.4)
- Environmental Water Program (KBRA Section 20)

The major plans to be developed include the On-Project Plan, the Off-Project Water Settlement, and the development of a Power for Water Management Plan. Plans including the Winter Shortage Plan, Drought Plan, Emergency Response Plan, Climate Change Evaluation, and Off-Project Reliance Program Plan are intended to help water users be better prepared for both reasonably foreseeable conditions and unexpected conditions. Winter shortage, drought, and climate change are reasonably foreseeable circumstances that could affect the amount of water available to users on Reclamation's Klamath Project. The Emergency Response Plan is intended to address necessary actions and coordination that may be required in the event of a failure of water diversion facilities or dikes.

To achieve environmental water goals during the interim period, the Interim Flow and Lake Level Protection Program would involve purchase or lease of water rights from willing sellers to increase the amount of water in the Klamath River and Upper Klamath Lake until permanent instream water supply enhancements could be put into effect.

The Off-Project Reliance Program is intended to provide a method for responding to unexpected circumstances affecting water availability downstream of Upper Klamath Lake that could affect the amount of water available for irrigation in the Off-Project Area. Due to the way water rights are prioritized, circumstances that affect water availability downstream of Upper Klamath Lake could affect on-Project users which in turn could affect off-Project users.

The purpose of the Power for Water Management Program is to provide affordable electricity to on- and off-Project power users who have enrolled in the program. This program is only broadly defined in the KBRA and includes an Interim Power Program, a Federal Power Program to supply low cost federal preference power, and a Renewable Power Program to increase efficiency and develop renewable energy sources.

The Environmental Water Program includes a set of projects to improve the real time management of water in the Upper Basin through such measures as the installation of water flow monitoring and snowpack gauges.

5.1.5.3 Diversion Limitations on Reclamation's Klamath Project

A cornerstone of the KBRA is the agreement to limit the amount of water that would be diverted for Reclamation's Klamath Project (KBRA Section 15 and Appendix E-1). These limitations would reduce the availability of irrigation water to approximately 100,000 acre-feet less than current demands in the driest years. Implementation of the diversion limitations would include assurances of increased reliability of diversions.

Under the proposed limitations, the amount of water that would be diverted to on-Project users, including the Klamath Basin National Wildlife Refuge System, varies by season and by water year forecast (whether a year is forecast to be wet or dry) (Table 5-2). The Natural Resources Conservation Service 50 percent exceedance forecast for net inflow to Upper Klamath Lake is used to set diversion limits. The 50 percent exceedance forecast is a prediction that there is a 50 percent chance that the actual stream flow will exceed the forecast value (and a 50 percent chance that flows will be less than the forecast value). Although Reclamation's Klamath Project diverts water from a variety of sources, the Upper Klamath Lake forecast would be used to set the diversion limits each spring and would generally characterize whether a particular year is expected to be wet or dry.

Table 5-2. Diversion Limitations on Reclamation's Klamath Project per KBRA Appendix E-1

Season	Forecast[2]	Diversion Limit
Phase I [1]		
March–October	287,000 AF or less	378,000 AF (which includes 48,000 AF for the refuges)
	287,000AF to 569,000 AF	378,000 AF to 420,640 AF (which includes from 48,000 AF to 55,640 AF for refuges) [3]
	More than 569,000 AF	445,000 AF (which includes 60,000 AF for refuges)
November–February	N/A	80,000 AF (which includes 35,000 AF for the refuges)
Phase II [1]		
March–October	287,000 AF or less	388,000 AF (which includes 48,000 AF for the refuges)
	287,000AF to 569,000 AF	388,000 AF to 430,640 AF (which includes from 48,000 AF to 55,640 AF for refuges) [4]
	More than 569,000 AF	445,000 AF (which includes 60,000 AF for refuges)
November–February	N/A	80,000 AF (which includes 35,000 AF for the refuges)

Key:
AF: acre-feet
Notes:
[1] Phase I of the diversion limitations represent the baseline agreement. Phase II allows additional diversions up to 10,000 AF under certain circumstances and would apply after i) the physical removal of the dams and a free-flowing condition and volitional fish passage has been restored; or ii) 10,000 AF of new storage has been developed in the upper basin; or iii) the Klamath Basin Coordinating Council on or after February 1, 2020 determines that the increase is appropriate based on the recommendations of the Technical Advisory Team.
[2] "Forecast" means the March 1 Natural Resources Conservation Service 50% exceedance forecast for net inflow to Upper Klamath Lake during the period of April 1 to September 30.
[3] The Phase I allowable diversion in thousands of acre-feet is calculated by the formula 378 + {42.64 x [(Forecast – 287) / 282]} and the refuge allocation is calculated by the formula 48 + {7.64 x [(Forecast – 287) / 282]}.
[4] The Phase II allowable diversion in thousands of acre-feet is calculated by the formula 388 + {42.64 x [(Forecast – 287) / 282]} and the refuge allocation is calculated by the formula 48 + {7.64 x [(Forecast – 287) / 282]}.

During the interim period (between the effective date and full implementation of the limits on water diversions to Reclamation's Klamath Project), the water diversion to Reclamation's Klamath Project users would conform to these limits as closely as possible. The On-Project Plan would identify what measures might be needed to fully implement the diversion limitations. Full implementation of the On-Project Plan is defined as completion of any measures necessary to allow full implementation of the diversion limitations.

The diversion limitations would not be binding on the parties to the KBRA until Appendix E-1 is filed in an appropriate forum. Appendix E-1 is currently formatted as a filing in the Oregon Water Resources Department (OWRD) water rights adjudication process; however, it is anticipated that that process will be completed before the Appendix is filed. In that case, the appendix would be reformatted for filing with the most appropriate forum and context, which likely would include a filing with OWRD as it concerns matters of water rights. Prior to filing, the appendix would be signed by the USFWS and irrigation districts within Reclamation's Klamath Project.

Appendix E-1 cannot be filed until the following actions are completed:

1. Notice and publication by the Secretary making assurances with respect to tribal water and fishing rights final and permanent. The Secretarial Notice would be published once the following conditions have been met:

    i. On-Project Plan is drafted and fully implemented

    ii. Wood River Restoration Project NEPA analysis and ESA consultation completed and funding secured

    iii. Agency Lake/ Barnes Ranches Project NEPA analysis and ESA consultation completed and funding secured

    iv. WURP funded

    v. Iron Gate, Copco 1, Copco 2, and J.C. Boyle Dams removed and a free flowing condition restored

2. Tribal water rights assurances are finalized which requires completion of conditions 1.iv and 1.v from above and the following conditions:

    i. Federal authorizing legislation enacted that authorizes federal agencies to become parties to the KBRA and to implement its provisions

    ii. Funding secured for plan development and implementation of Phase I and II Fish Restoration plans, Phase I Fish Reintroduction plans, Fish Monitoring Plan, and Interim Flow and Lake Level Program

    iii. Funding secured for tribal resource management programs and economic development programs

   iv. Funding secured for Klamath Tribes acquisition of Mazama Forest

   v. Petition for an interim fishing site granted to Klamath Tribes

3. Either a General Conservation Plan or a Habitat Conservation Plan has been completed by non-federal irrigators within Reclamation's Klamath Project, USFWS, and NOAA Fisheries Service, and a Section 10 Incidental Take Statement under the ESA issued

4. Final judgment by state courts that the KBRA is a valid agreement

On-Project Plan

The On-Project Plan is intended to align supply and demand for water users within Reclamation's Klamath Project and set the framework for implementation of the diversion limits (KBRA Section 15.2). The plan is to include techniques to monitor and prevent groundwater pumping from having an adverse effect on springs within the basin. An adverse effect is defined as a 6 percent reduction in flow.

The On-Project Plan would include details on management of the Refuge Allocation which would be the amount of water that the Lower Klamath NWR and Tule Lake NWR would receive from water diversions and appropriate responses in the event of summer or winter shortages. The KBRA specifies how and under what circumstances a deficit would be shared among the on-Project users and the NWRs in the event of a summer shortage of water available for diversion. A plan for management of winter shortages is to be developed. The On-Project Plan would reference the Winter Shortage Plan, the Drought Plan, the Emergency Response Plan, and other plans to be developed as appropriate.

Implementation of the On-Project Plan is expected to take up to 5 years and the deadline for full implementation is no later than 2022. To implement the On-Project Plan, managers might need to take a variety of actions including acquisition or negotiation of easements or forbearance agreements, land acquisitions, implementation of efficiency or conservation measures, development of groundwater sources, or creation of additional storage.

5.1.5.4 Off-Project Water Settlement

The Off-Project Water Settlement is intended to provide a forum for resolving long-standing water disputes between the Upper Klamath Water Users Association, Klamath Tribes, and the Bureau of Indian Affairs (KBRA Section 16) in the Off-Project Area. The Off-Project Area includes the Wood River, Sprague River, Sycan River, and Williamson River sub-basins. The intent is to negotiate a settlement that resolves the off-Project irrigators' contests to claims in Tribal Cases under the Klamath Basin water rights adjudication process. In the event that not all such contests are resolved through this process, then the intent is to provide reciprocal assurances for maintenance of instream flows and reliable irrigation water deliveries to the Off-Project Area. The anticipated schedule for development and implementation of the Off-Project Plan is between 2012 and 2021 (KBRA Appendix C-2).

5.1.5.5 Water Use Retirement Program

The voluntary WURP is intended to permanently increase the flow of water into Upper Klamath Lake by 30,000 acre-feet per year to support restoration of fish populations (KBRA Section 16.2.2). In exchange for this benefit to the Upper Klamath Lake fisheries, the Klamath Tribes would be willing to settle certain water rights claims with water users in the Upper Basin.

The WURP is intended to be part of the Off-Project Water Settlement, but may also be implemented independently by the Upper Basin Team. The WURP could take up to 10 years to be fully implemented and the KBRA intends for implementation to start with the completion of the Off-Project Water Settlement in 2012. The WURP may be implemented through a variety of measures including retirement of water rights, forbearance agreements, short-term water leasing, split season irrigation, upland management techniques, water efficiency measures, dry land cropping, and natural storage improvements such as wetlands or improved riparian areas. OWRD would determine when the required 30,000 acre-feet of water would be permanently assigned to Upper Klamath Lake.

5.1.5.6 County and Tribal Programs

County and Tribal programs under the KBRA include the following:

- Regulatory assurances that adverse impacts on communities would be minimized
- Economic development programs for local governments and Tribes
- Tribal fisheries and natural resource conservation management programs

Regulatory Assurances

The KBRA provides for reintroduction of salmon and other aquatic species in the Upper Basin, which could have potential regulatory or other legal consequences for land or water users upstream of the current site of Iron Gate Dam. While the KBRA does not modify existing laws or create exemptions, it identifies several actions that would help to avoid additional regulatory burdens in the event that listed fish species are reintroduced to the Upper Basin. These actions include a commitment from Reclamation to construct entrainment reduction facilities such as fish screens to prevent fish from entering the diversion facilities on Reclamation’s Klamath Project. The parties to the KBRA have also agreed to coordinate with each other and communicate openly on a wide variety of issues in an effort to avoid surprises so that solutions can be sought without acrimony.

The development of either a General Conservation Plan or a Habitat Conservation Plan is identified as a means to secure an incidental take permit under Section 10(a)(1)(B) of the ESA and as one means to avoid or minimize regulatory or other obligations arising from the reintroduction of fish species to the Upper Basin. In that light, NOAA Fisheries Service and USFWS will lead the development of a General Conservation Plan or Plans for use by KBRA parties or others to apply for incidental take permits under the Endangered Species Act.

County Programs

The County Programs under the KBRA were structured with the recognition that there may be impacts and opportunities for each of the counties within the Klamath Basin. Klamath County has agreed to develop a plan for economic development if funding is available (KBRA Section 27). Funding would potentially come from KBRA funding and from state business development funds. The California Water Bond funding legislation, scheduled for a vote in 2012, proposes funding for economic development within Siskiyou County. Humboldt and Del Norte Counties are not included in this economic development fund. Funds remaining in the Water Bond fund after covering dam facility removal, CEQA mitigation, and actions to secure the City of Yreka's water supply, may be used for fish restoration projects within Siskiyou, Humboldt, and Del Norte Counties.

Similarly there may be property tax revenue losses and gains from the various effects of the KBRA. Property tax revenue changes could occur due to reduced agricultural land values from a) a reduction in water deliveries and b) the surrender of significant water rights. The Klamath County Program within the KBRA includes a provision to compensate Klamath County for these potential revenue changes upon the availability of funding. The anticipated schedule for identification of potential property tax impacts and compensation payments is 2016 (KBRA Appendix C-2). County programs for Siskiyou, Humboldt, and Del Norte Counties do not include a provision for compensation for changes in property tax revenues that may result from the removal of the hydroelectric facilities.

Tribal Programs

The KBRA includes provisions for each of the affected tribes (the Klamath Tribes, Karuk Tribe, and Yurok Tribe) to receive assistance in developing their capacity to participate in both fisheries management and conservation management activities within the basin (KBRA Sections 31 and 32). In addition, each tribe would prepare an economic development plan and work towards implementing that program (KBRA Sections 31 and 33). Preparation of economic development plans is anticipated to occur in 2013.

The Klamath Tribes have been working with the Trust for Public Lands and have acquired an option to purchase the Mazama Forest in the upper basin, once a part of the Tribes' reservation lands. The parties to the KBRA agree to support the Tribes' efforts to secure funding and complete the purchase of this forest land (KBRA Section 33.2). Final acquisition of Mazama Forest is anticipated to occur in 2012 or 2013. Completion of the purchase of Mazama Forest is one of the key milestones towards the filing of KBRA Appendix E-1 and the full implementation of the diversion limits to Reclamation's Klamath Project.

Under Section 34 of the KBRA, the Klamath Tribes have petitioned the California Fish and Game Commission to establish an interim fishing site in the reach of the Klamath River between Iron Gate Dam and the Interstate 5 Bridge. Petitions are reviewed on an annual basis. The CDFG staff must first make a recommendation on a pending petition to the Commission before the Commission may act. Recommendations must be received by the Commission in January for a decision in that year. It is possible that the Pacific Fishery Management Council may be involved in reviewing and approving this interim fishing site as well, in which case the approval process could take longer than a year. The grant of this petition is one of the key milestones toward implementation of the KBRA.

5.1.6 Option: Mechanical Sediment Removal

Mechanical sediment removal may be an option to reduce adverse water quality effects related to sediment erosion generated during drawdown of J.C. Boyle, Copco 1, and Iron Gate Reservoirs. This option includes dredging sediment before and during reservoir drawdown to reduce the quantity of sediment released downstream. This option is under analysis to determine if it could be a feasible and effective way to reduce effects.

Based on engineering analysis of reservoir sediments, reservoir depth, and downstream aquatic species sensitivities, hydraulic dredging with designated disposal sites in close proximity (within 2 miles) to the reservoirs would be the best option for managing reservoir sediments. Hydraulic dredging would occur simultaneously at the three reservoirs, in two stages. The first stage would be before reservoir drawdown. The hydraulic dredges would remove sediment in the reservoirs up to the optimal depth of the dredge (estimated at 25 feet). During the second stage, dredging in each reservoir would progress with reservoir drawdown removing the greatest quantity of sediment possible in the time available. Dredging would leave at least one foot of sediment at the bottom of each reservoir to protect any buried cultural or archeological sites.

The DRE would use flexible piping to hydraulically pump the dredged slurry to a potential disposal site. Disposal sites would either retain the total quantity of sediment and water (ratio of 15 percent sediment to 85 percent water) or a percentage of the water could be decanted and returned to the river or applied to land. Decanting the sediment slurry would ultimately reduce the land requirement for sediment disposal. There are potential locations for disposal facilities around the reservoirs on land belonging to the federal government, PacifiCorp, or a state agency. Most of the potential disposal facilities sites have land slopes exceeding 10 percent. Disposal site containment embankments would be engineered structures estimated at a height of 20 feet, similar to levees, and would likely require dam safety inspection and permitting.

5.1.6.1 J.C. Boyle Reservoir

J.C. Boyle Reservoir has an estimated 940,000 yd^3 of erodible sediment. The sediment thickness is relatively thin in the upper portions of the reservoirs and increasingly thickens to 20 feet near J.C. Boyle Dam. Water depths range from two feet up to 40 feet. The largest hydraulic dredge that the DRE could use effectively for sediment removal has a maximum effective dredge depth of 25 feet. This dredge could access a fairly large amount of the reservoir sediments prior to drawdown.

To remove the sediment, the DRE would use one dredge with a 16-inch-diameter cutterhead and discharge pipeline. This dredge would operate for two shifts (16 hours per day), 6 days a week, at a maximum production capacity of 700 yd^3 per hour. The production efficiency, based on dredge length, depth, dredge swing angle, thickness of the sediment, and depth of the cut, would be about 75 percent (Johnson Undated). This results in an approximate production rate of 7,200 yd^3 per calendar day.

The DRE would put the dredge in the water on the west shore of the reservoir on Highway 66, near the Topsy Recreation Site at the Route 66 Bridge (see Figure 5-6). The DRE would most likely access this site using the Highway 66 Bridge crossing the reservoir. Currently the bridge is a one-lane bridge with an unknown weight capacity, although the maximum limit on Highway 66 is 40 tons of gross weight. The access site would provide an area for equipment staging.

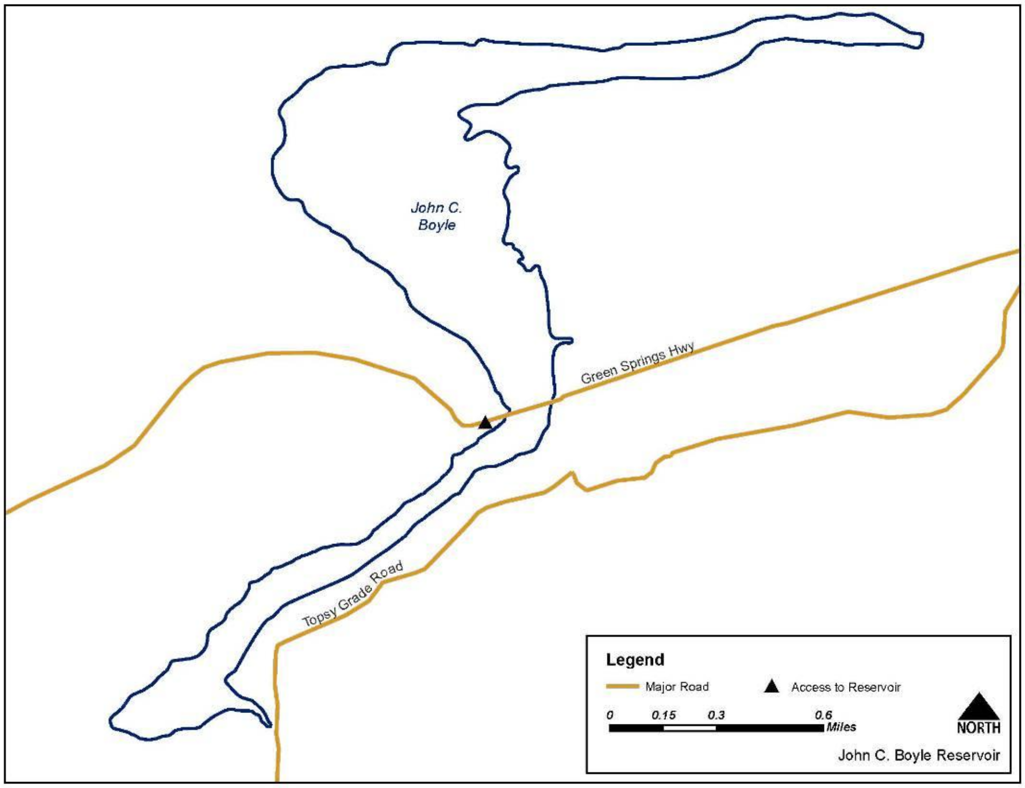

Figure 5-6. J.C. Boyle Reservoir Access

Hydraulic dredging operations would start before reservoir drawdown. During this time, the DRE would remove the accessible sediment in water less than 25 feet in depth. The DRE could remove approximately 335,600 yd^3 of sediment before drawdown in approximately 47 days, based on the 7,200 yd^3 per calendar day production rate.

Dredging operations would continue simultaneously with reservoir drawdown, removing the sediment as reservoir areas became available in water shallower than 25 feet. Assuming a starting reservoir elevation of 3,793.0 feet and ending at elevation 3,762.0 feet, complete drawdown would take about 31 days in a normal water year. Drawdown would take less time in a dry water year and more time in a wet year.

The DRE could remove approximately 219,800 yd^3 of additional reservoir sediment during the drawdown period (about 31 days). Table 5-3 summarizes the maximum amount of sediment that could be removed before and during reservoir drawdown. This approach would strand the dredge in the reservoir near the J.C. Boyle Dam. The DRE would remove the dredge at Topsy Grade Road with cranes and other means during dam removal.

Table 5-3. J.C. Boyle Reservoir Maximum Sediment Removal

Assumptions	
Drawdown rate	Average of 1 foot/day
Total amount of eroded sediment	940,000 yd^3
Reservoir elevation prior to drawdown	3,793.0 feet
Calculated Quantities	
Pre-drawdown duration	47 days
Number of dredges for pre-drawdown dredging	1
Pre-drawdown sediment removal	335,600 yd^3
Drawdown duration	31 days
Number of dredges during drawdown	1
Sediment removal during drawdown	219,800 yd^3
Total sediment removal	**555,400** yd^3
Percentage of erodible sediment removed	**59.1**

Key:
yd^3: cubic yards

The DRE could remove an estimated 555,400 yd^3, or 59.1 percent of erodible sediment, using hydraulic dredging. The slurry would contain about 15 percent solids (by weight). The total volume of slurry requiring management and disposal would be approximately 3,702,667 yd^3.

The DRE would construct a diked containment area to hold the sediment slurry, allowing the sediment to settle out and the water to either decant or evaporate. Assuming that the DRE would decant the slurry prior to sending it to the containment area, the containment area would need a parcel of land of approximately 57 acres, using 20 foot high containment dikes. Land directly around J.C. Boyle might accommodate this size of sediment management and disposal site. As shown in Figure 5-7, several areas of relatively flat land (slopes less than 10 percent) surround the reservoir that are privately-owned or owned by PacifiCorp. The Sportsman's Park recreation area, owned by PacifiCorp, would be a good location but cannot be used because the land will stay a recreational park. The DRE would likely construct several sediment disposal areas to create enough volume to hold the decanted slurry. After dredging was complete, the water would slowly drain or evaporate out of the containment area. The DRE would revegetate the sediment-covered land to stabilize the sediment after water removal.

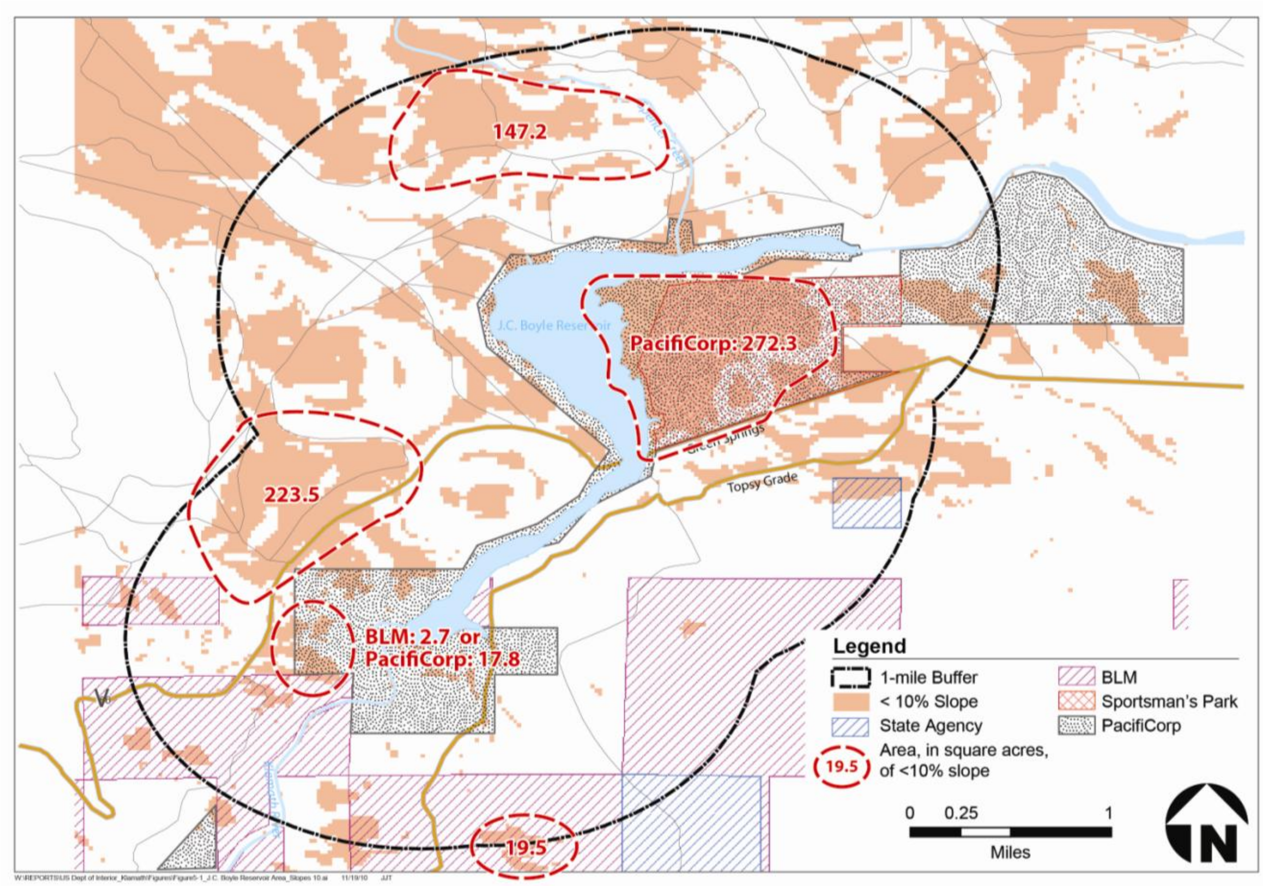

Figure 5-7. J.C. Boyle Reservoir Area (Slopes <10%)

5.1.6.2 Copco 1 Reservoir

Copco 1 Reservoir has an estimated 2,700,000 yd^3 of erodible sediment. The sediment thickness is relatively uniform throughout the reservoir, ranging from 0.2 to 10.4 feet. Water depths in Copco 1 Reservoir range from 5 feet to 110 feet. The largest hydraulic dredge that the DRE could use effectively has a maximum effective depth of 25 feet. The dredge could access only a relatively small area of the reservoir sediments before drawdown.

The DRE would use up to three dredges on the reservoir, each with a 16-inch-diameter cutterhead and pipeline and an approximate production rate of 7,200 yd^3 per calendar day. The DRE would put the dredges in the water on the north shore of the reservoir on Copco Road (Figure 5-8). The site would provide an area for equipment staging.

Hydraulic dredging operations would start before reservoir drawdown. During this time, the DRE would use two dredges to remove accessible sediment in water less than 25 feet in depth. The start of hydraulic dredging operations would occur prior to the start of reservoir drawdown using two dredges. The DRE could remove approximately 176,700 yd^3 of sediment before drawdown in approximately 12 days, based upon the 7,200 yd^3 per day production rate for two dredges.

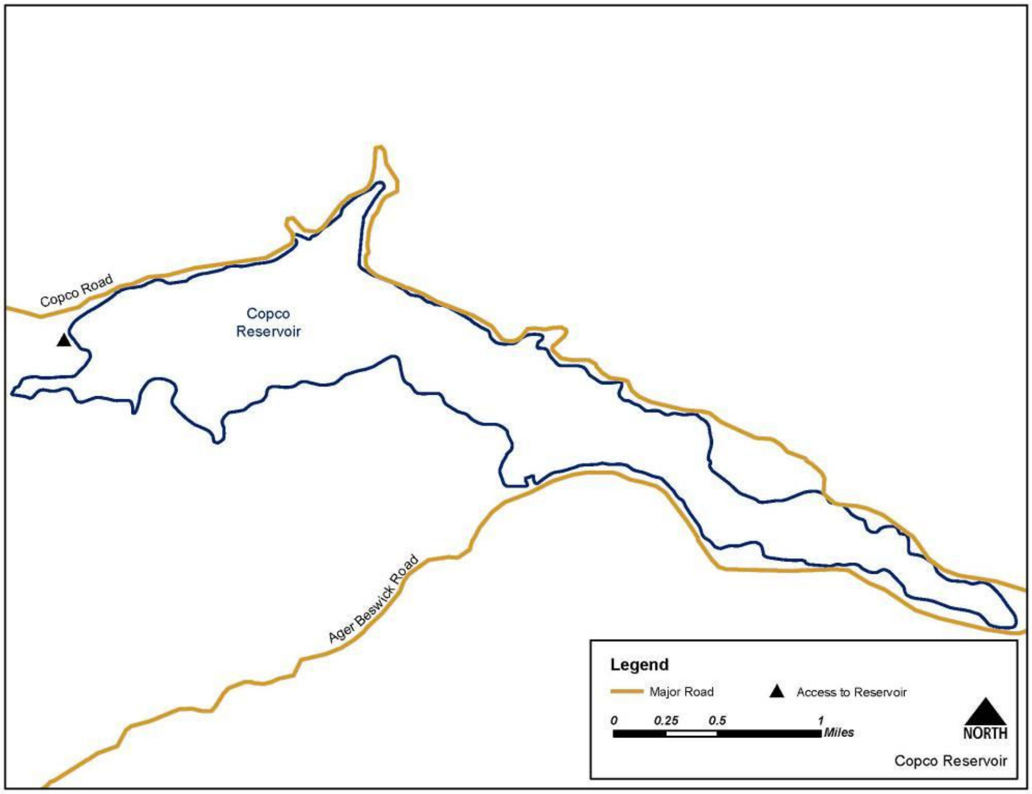

Figure 5-8. Copco 1 Reservoir Access

Dredging operations would continue simultaneously with reservoir drawdown, removing the sediment as areas became available in water shallower than 25 feet. The DRE would use two dredges for the entire duration of drawdown, and a third for a portion of the drawdown period. The drawdown scenario assumes a starting reservoir elevation of 2,606.0 feet and ending at 2,484.0 feet, with drawdown taking approximately 108 days under a normal water year. This approach would strand the dredges in the reservoir near the Copco 1 Dam. The DRE would remove the dredge along Copco Road with cranes and other means during dam removal.

The DRE could remove approximately 1,277,100 yd^3 of additional reservoir sediment during the drawdown period. Table 5-4 summarizes the maximum amount of sediment that could be removed before and during drawdown from Copco 1 Reservoir.

Table 5-4. Copco 1 Reservoir Maximum Sediment Removal

Assumptions	
Drawdown rate	Average of 1 foot/day to elevation 2,590.0 feet, then an average of 1.75 feet/day to elevation 2,529.0, then an average of 2.25 feet/day to elevation 2,484.0
Total amount of eroded sediment	2,700,000 yd^3
Reservoir elevation prior to drawdown	2,606.0 feet
Calculated Quantities	
Pre-drawdown dredging duration	12 days
Number of dredges for pre-drawdown dredging	2
Pre-drawdown sediment removal	176,700 yd^3
Drawdown duration	108 days
Number of dredges during drawdown	2 to 3
Sediment removal during drawdown	1,277,100 yd^3
Total sediment removal	**1,453,800 yd^3**
Percentage of eroded sediment removed	**53.8**

Key:
yd^3: cubic yards

The DRE could remove approximately 1,453,800 yd^3 of sediment as slurry with the hydraulic dredge. The slurry would contain approximately 15 percent solids (by weight). The total volume of slurry requiring management and disposal would be approximately 9,692,000 yd^3. Assuming that the DRE would decant the slurry prior to sending it to the containment area, the containment area would need a parcel of land of approximately 150 acres, using 20 foot high containment dikes.

As shown in Figure 5-9, the lands around Copco 1 Reservoir have relatively steep slopes, and few areas have less than a 20 percent slope. The largest area with less than a 20 percent slope is approximately 519.4 acres of PacifiCorp-owned land, approximately a mile and a half northeast from the reservoir. This parcel of land would hold the decanted slurry. After dredging is complete, the water would slowly drain out of the containment area. The DRE would revegetate the sediment-covered land to stabilize the sediment after water removal.

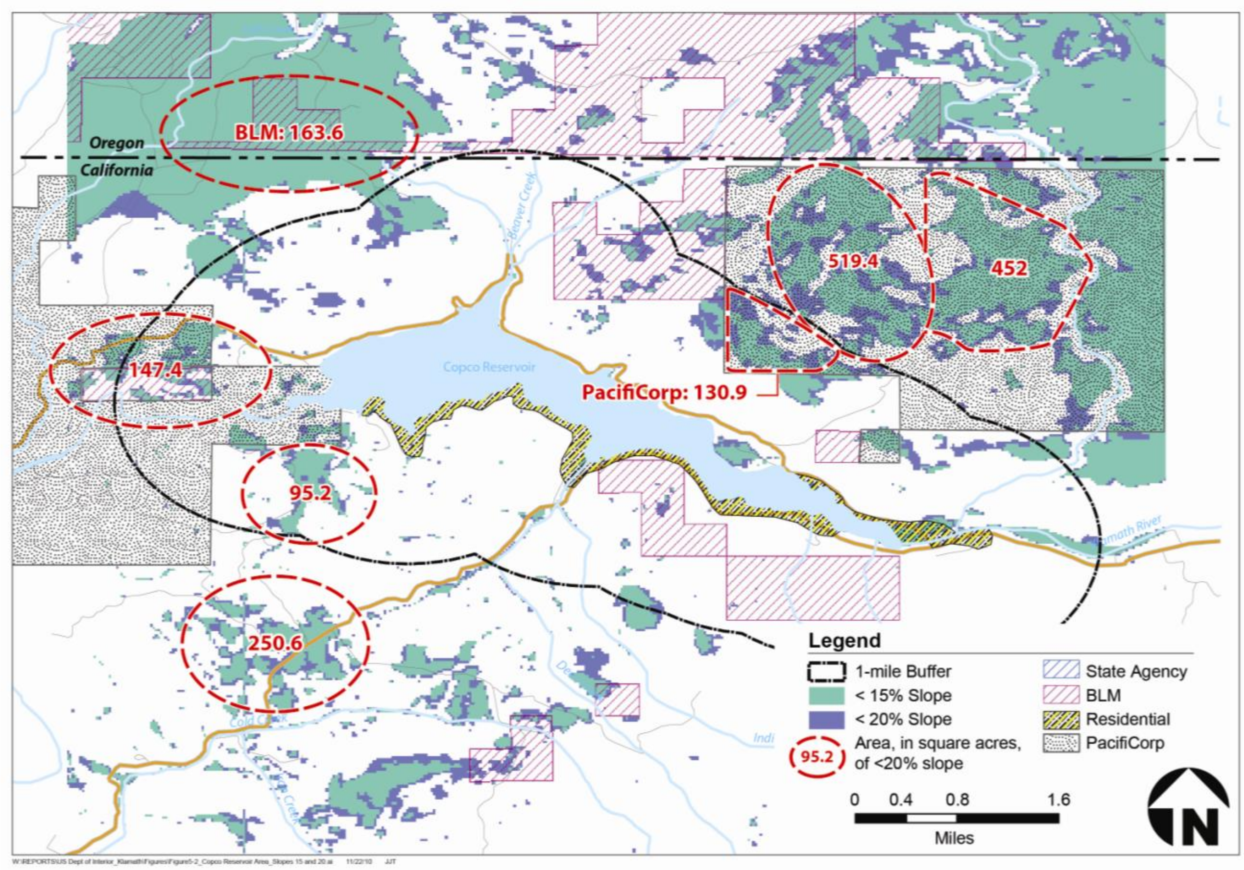

Figure 5-9. Copco 1 Reservoir Area (Slopes <15% and <20%)

5.1.6.3 Iron Gate Reservoir

Iron Gate Reservoir has an estimated 2,830,000 yd^3 of erodible sediment. The sediment thickness is relatively uniform throughout the reservoir, ranging from 1 to 6 feet in water depths up to 160 feet. The largest hydraulic dredge that the DRE could use effectively for sediment removal has a maximum effective depth of 25 feet. As with Copco 1 Reservoir, the dredge has an ability to access only a relatively small area of the reservoir sediment without drawdown.

To remove the sediment, the DRE would use up to three dredges with 16-inch-diameter pipelines and an approximate production rate of 7,200 yd^3 per calendar day per dredge. The DRE would put the dredge in the water on the south shore of the reservoir by an access road off of Lake View Road (Figure 5-10). The site would provide an area for equipment staging.

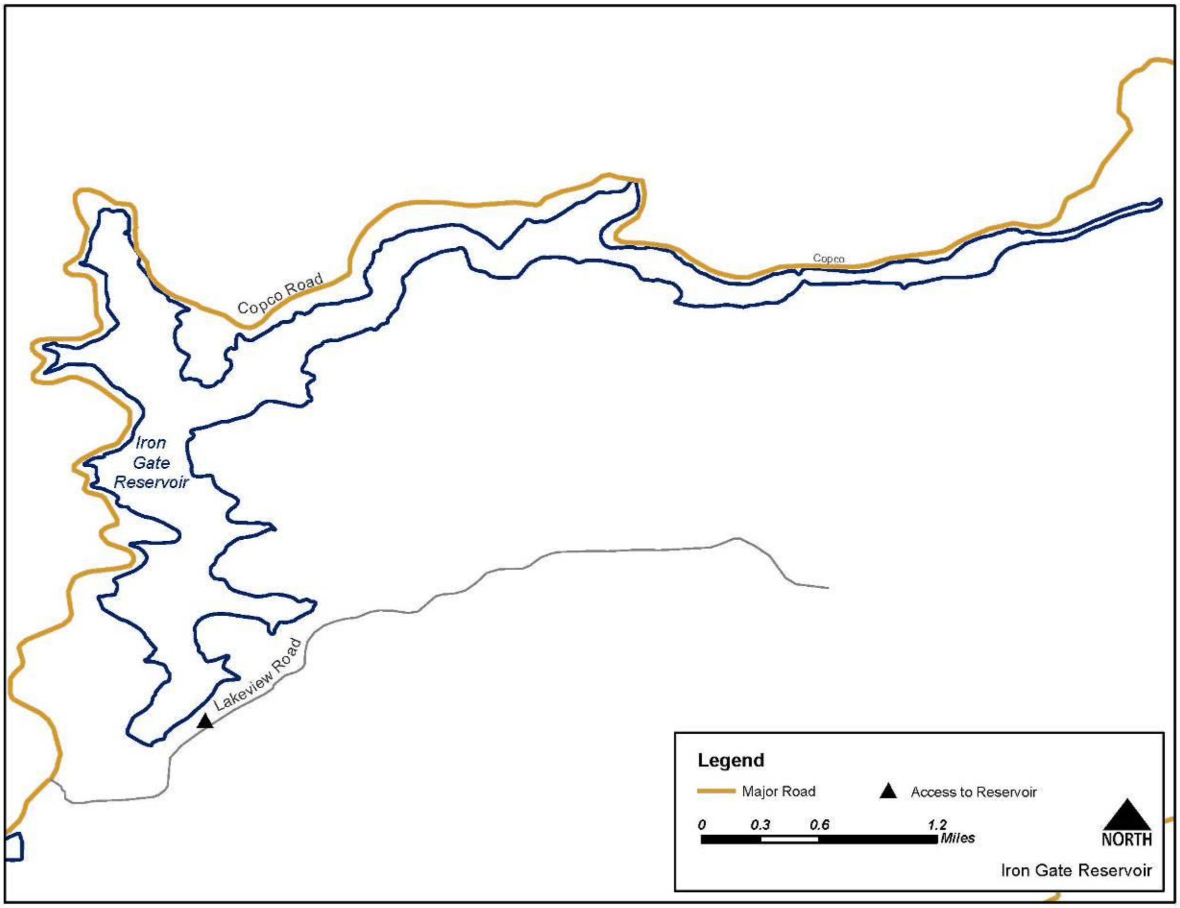

Figure 5-10. Iron Gate Reservoir Access

Hydraulic dredging operations would start before reservoir drawdown. During this time, the DRE would use two dredges to remove the accessible sediment in water depths less than 25 feet. The DRE could remove approximately 106,000 yd^3 before drawdown in approximately 7 days, based on the 7,200 cubic yards per day production rate for each dredge.

Dredging operations would continue simultaneously with reservoir drawdown, removing the sediment as areas became available. The DRE would use three dredges during drawdown to remove sediment. Assuming a starting elevation of 2,328.0 feet and an ending elevation of 2,202.0 feet, complete drawdown would take about 42 days in a normal water year. The DRE could remove approximately 733,100 yd^3 of additional reservoir sediment during the drawdown period. This approach would strand the dredges in the reservoir near the Iron Gate dam. The DRE would remove the dredge with cranes and other means at the dam site during dam removal. Table 5-5 summarizes the maximum amount of sediment that could be removed before and during drawdown.

Table 5-5. Iron Gate Reservoir Maximum Sediment Removal

Assumptions	
Drawdown rate	Average of 3 feet/day
Total amount of eroded sediment	2,830,000 yd^3
Reservoir elevation prior to drawdown	2,328.0 feet
Calculated Quantities	
Pre-drawdown duration	7 days
Pre-drawdown sediment removal	106,000 yd^3
Number of dredges for pre-drawdown dredging	2
Drawdown duration	42 days
Number of dredges during drawdown	3
Sediment removal during drawdown	733,100 yd^3
Total sediment removal	**839,100 yd^3**
Percentage of eroded sediment removed	**29.7**

Key:
yd^3: cubic yards

The DRE could remove an estimated 839,100 yd^3, or approximately 29.7 percent of erodible sediment, using hydraulic dredging. The slurry would contain approximately 15 percent solids (by weight). The volume of the sediment slurry requiring management and disposal would be approximately 5,594,000 yd^3.

As shown in Figure 5-11, the lands around Iron Gate Reservoir have relatively steep slopes, with few areas that have less than a 20 percent slope. The federal government and PacifiCorp own several small parcels of land around the reservoir. Assuming that the DRE would decant water prior to sending the slurry to the containment area, the containment area would need, a parcel of land that is approximately 87 acres. Figure 5-11 shows a 147.4-acre parcel that could hold the decanted slurry. After dredging was complete, the water would slowly drain out of the containment area. The DRE would revegetate the sediment-covered land to stabilize the sediment after water removal.

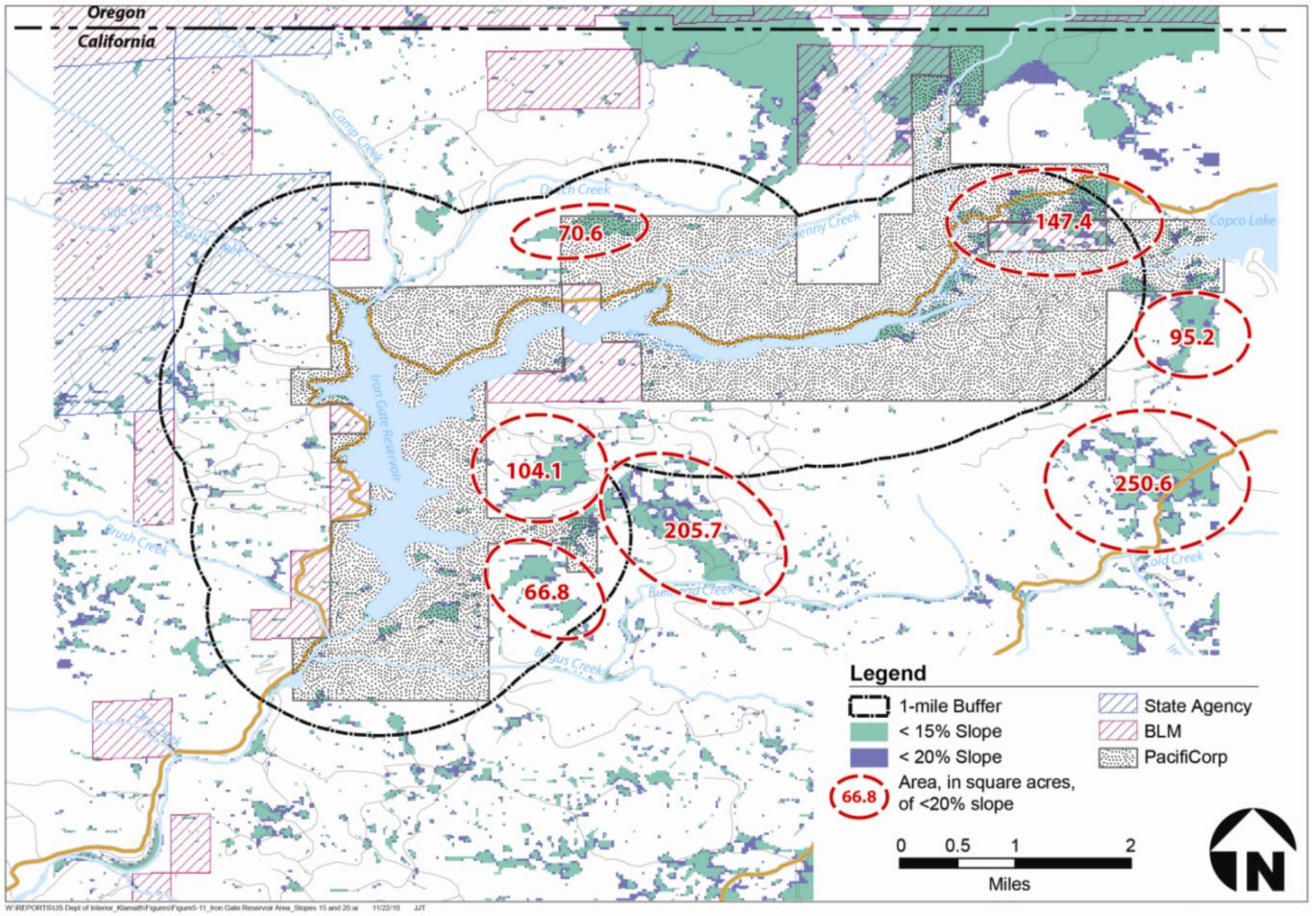

Figure 5-11. Iron Gate Reservoir Area (Slopes <15% and <20%)

5.2 Alternative 3 – Partial Facilities Removal of Four Dams

5.2.1 Features of the Partial Facilities Removal of Four Dams Alternative

Two of the primary goals of dam removal on the Klamath River are to restore volitional fish passage and a free-flowing river conditions at each dam site in order to advance restoration of anadromous fish populations. This goal would be achieved through full dam removal, but could also be achieved through partial dam removal where practical. The schedule for Partial Facilities Removal of Four Dams would be the same as for Full Facilities Removal.

Partial Facilities Removal of Four Dams would remove enough of each dam to allow free-flowing river conditions and volitional fish passage at all times. Under the partial removal alternative, portions of each dam would remain in place along with ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes. Some of these remaining features would likely require perpetual maintenance and security measures to prevent unauthorized entry. All tunnel openings would be sealed with reinforced concrete to eliminate trespass concerns. All oils, hydraulic fluids, and other potential contaminants found in powerhouses and machinery would be removed prior to final decommissioning and securing of buildings. Table 5-6 provides a summary of facilities that would be removed or retained under the Partial Facilities Removal of Four Dams Alternative. All facilities that would be retained in the Partial Facilities Removal of Four Dams Alternative would be removed in the Full Facilities Removal of Four Dams Alternative. The Partial Facilities Removal of Four Dams Alternative also includes implementation of the KBRA (see Section 5.1.5).

Table 5-6. Summary of Features to be Removed or Retained with the Partial Facilities Removal of Four Dams Alternative.

Feature	J.C. Boyle	Copco 1	Copco 2	Iron Gate
Embankment/earth fill dam	Remove	N/A	Retain	Remove
Concrete dam structure	Remove	Remove	Remove	N/A
Concrete wingwalls	N/A	N/A	Retain Right Wall	N/A
Reservoir power intake structure	Retain	Retain	Retain	Remove
Spillway	Remove	Remove	Remove	Retain
Spillway control gates	Remove	Remove	Remove	N/A
Concrete fish ladder	Remove	N/A	N/A	Remove
Concrete flume headgate structure	Retain	N/A	N/A	N/A
Concrete canal intake screen	Retain	N/A	N/A	N/A
Concrete flume	Remove Walls	N/A	N/A	N/A
Concrete canal spillway	Remove	N/A	N/A	N/A
Tunnel intake structure	Remove	Retain	Retain	Remove
Tunnel portals	Plug	Plug	Plug	Plug
Steel pipeline & supports	Retain	N/A	N/A	N/A
Steel surge tank	Remove	N/A	N/A	N/A
Wood-stave penstock	N/A	N/A	Remove	N/A
Penstocks, supports, anchors	Remove	Retain	Retain	Remove
Powerhouse building	N/A	Retain	Retain	Retain
Powerhouse gantry crane	Remove	N/A	N/A	N/A
Powerhouse concrete slab/structure	Retain	Retain	Retain	Retain
Powerhouse hazardous materials	Remove	Remove	Remove	Remove
Tailrace flume walls	Retain	N/A	N/A	N/A
Tailrace channel	Fill	Fill	Fill	Fill
Switchyard	Remove	Remove	Retain	Remove
Warehouse & support buildings	Remove	N/A	Retain	N/A
Fish Hatchery	N/A	N/A	N/A	Retain

The following sections describe the work limits and features for partial removal of each dam under this alternative. Section 5.2.4 describes the construction details for this alternative.

5.2.1.1 J.C. Boyle

See Section 5.1.1 for a description of J.C. Boyle Dam. Partial Facilities Removal would require the complete removal of the embankment section, gated concrete spillway section, and concrete cutoff wall to the bedrock foundation. The DRE would undertake the following actions:

- Remove the lower portion of the fish ladder to prevent potential fish stranding during peak flow events.
- Remove the spillway gates, deck, and piers to facilitate reservoir drawdown and to ensure sufficient discharge capacity during dam removal to prevent an overtopping failure of the embankment.
- Remove the abutment wall and upper portion of the fish ladder, because they could become unstable after the removal of the embankment and spillway sections.
- Recoat the 14-foot-diameter steel pipeline and supports to encapsulate potential heavy metals.
- Remove concrete walls for the water conveyance canal to allow drainage and animal migration, and prevent collapse due to rockfall.
- Remove the 78-foot-tall steel surge tank and the 150-ton gantry crane to prevent a potential future stability problem during a large seismic event.
- Remove the penstocks to avoid long-term maintenance issues related to the steel, which likely has coatings containing heavy metals.
- Plug the downstream tunnel portal with concrete to avoid unauthorized entry.
- Remove the switchyard and warehouse building.
- Fence and seal the powerhouse

Under the Partial Facilities Removal of Four Dams Alternative, the DRE would not remove the water intake structure, left abutment concrete gravity section, concrete headgate structure, intake screen, steel pipeline and supports, tailrace walls, and powerhouse concrete slab and structure, as shown in Figure 5-12. The DRE would not fill and stabilize the headcut downstream of the forebay overflow discharge canal (as in the Proposed Action) because it would require a large quantity of material that would not be available; partial removal would not produce as much concrete rubble as full removal would.

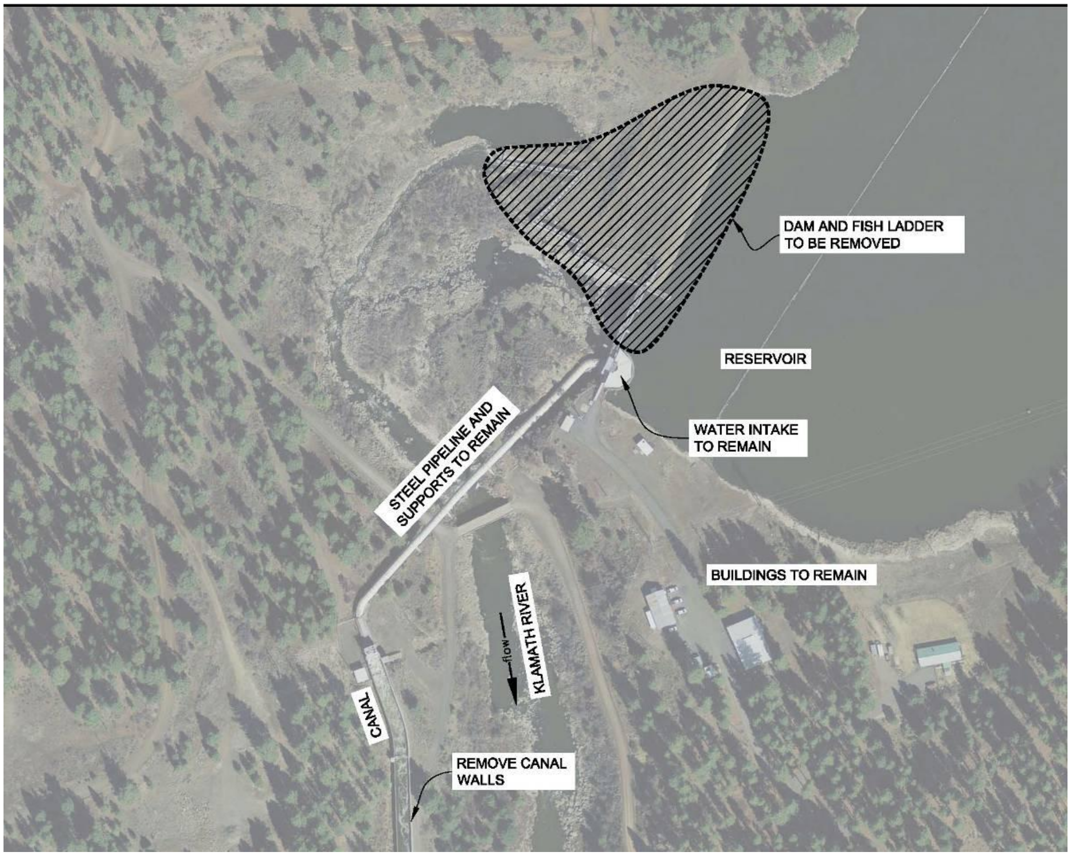

Figure 5-12. View of J.C. Boyle Dam Showing Portion of Dam and Fish Ladder for the Partial Facilities Removal of Four Dams Alternative

The DRE would leave the mechanical and electrical equipment in place with all power connections to the outside removed; however, the DRE would remove any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment. The DRE would also remove other mechanical and electrical equipment containing potentially hazardous materials.

5.2.1.2 Copco 1 Dam and Powerhouse

To create a free-flowing condition and volitional fish passage through the Copco 1 site, the DRE would take the following actions:

- Remove the concrete gravity arch dam and associated facilities (spillway gates, bridge deck, and piers) between the left abutment rock and the concrete intake structure on the right abutment, to 5 feet below the existing streambed level at the dam.
- Remove the two concrete gate houses on the right abutment intake structure if necessary to provide workspace for a large crane.

- Seal the downstream end of the intake tunnel portal with concrete to avoid unauthorized entry.
- Remove unused transmission lines, poles, and the switchyard.
- Seal and fence the powerhouse.

Under the Partial Facilities Removal of Four Dams Alternative, the DRE would not remove the power generation water intake structure, penstocks, and powerhouse. Retention of these structures would require long-term maintenance, including the preservation of any items with coatings containing heavy metals.

The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the J.C. Boyle Dam removal under this alternative.

5.2.1.3 Copco 2 Dam and Powerhouse

To create a free-flowing condition and volitional fish passage through the Copco 2 site, the DRE would take the following actions:

- Remove the concrete gated spillway structure and concrete end sill between the existing sidewalls (see Figure 5-13) as well as associated facilities (spillway gates, bridge deck, and piers).
- Remove wood-stave penstock.
- Remove equipment on the right abutment embankment section to facilitate construction access to the gated spillway.
- Seal and fence powerhouse.

Under the Partial Facilities Removal of Four Dams Alternative, the embankment section on river right, intake structure on river left, conveyance system to the powerhouse, and powerhouse would remain in place. Figure 5-14 shows an example of a partial dam removal project that retained portions of the dam while maintaining free-flow conditions and volitional fish passage.

A small portion of the downstream basin apron slab would remain intact for structural stability of the right sidewall, provided that a potential fish barrier would not result in the future.

The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the J.C. Boyle and Copco 1 Dam removals under this alternative.

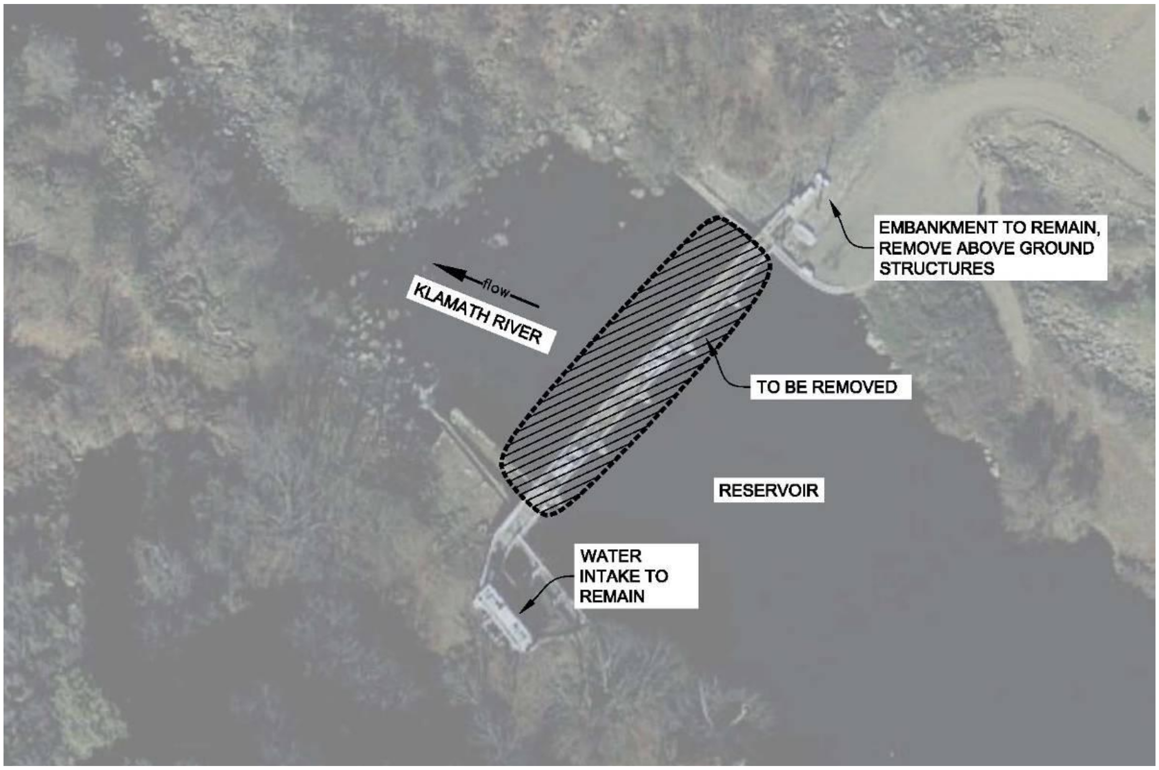

Figure 5-13. Copco 2 dam Showing Portion of Dam that would be removed for the Partial Facilities Removal alternative

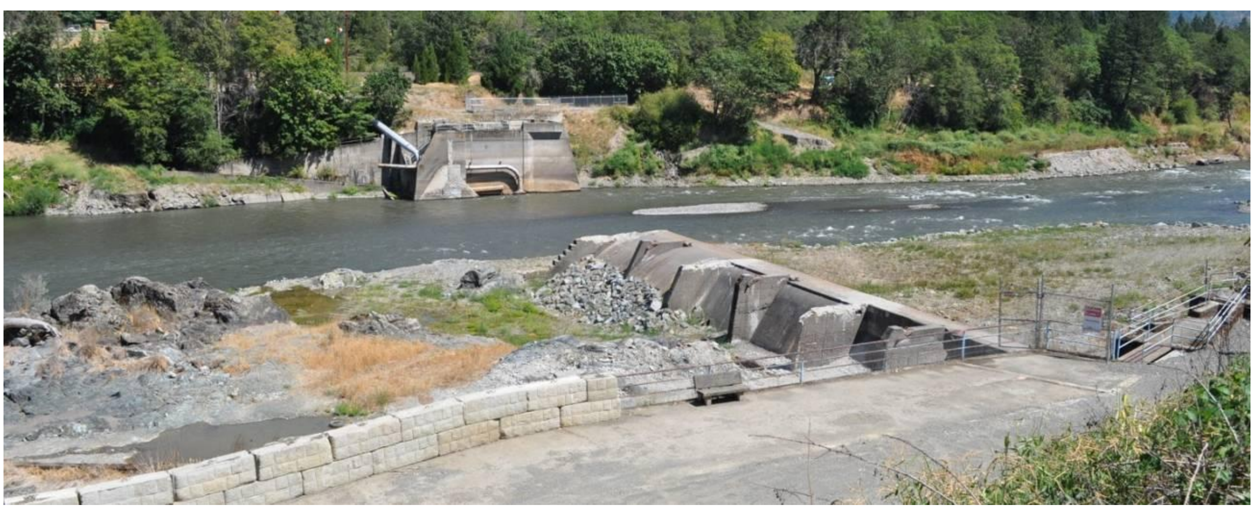

Figure 5-14. Example of Partial Dam removal showing Savage Rapids Dam on the Rogue River (2010)

5.2.1.4 Iron Gate Dam and Powerhouse

Prior to construction of Iron Gate Dam, the Klamath River had an average channel width of at least 70 feet during baseflow conditions in the area of the existing dam based on historical topographic surveys and cross-sections. During yearly high flow events, the channel expanded out onto a floodplain that consists primarily of bedrock material out to the toe of steep, bedrock walls. The bedrock canyon width is 200 to 250 feet at the base of the dam. Based on the historical channel width, the minimum width of the channel at the base of the dam should be approximately 100 feet or more to ensure the area is not a fish passage barrier at high flows. One check for this width is the bridge that is just downstream of the existing dam and has a span of 175 feet, based on structural drawings.

With a minimum notch of 100 feet at the base of the dam, the slopes of the remaining embankment material would need a maximum slope of 1.5H:1V for stability, and more likely, a slope of 2H:1V or flatter. In addition, the inner core of the earthfill dam would need a filter layer similar to the upstream and downstream sides of the dam for stability. A stable riprap blanket would cover the filter material to protect the remaining portion of the dam.

Figure 5-15 shows Iron Gate Dam with a 100-foot-wide notch at the base of the dam with 1.5H:1V side slopes or 2H:1V side slopes to the top of the dam. This figure illustrates that notching the dam would remove nearly the entire dam and would create the need to protect the newly exposed inner core of the dam for stability. The amount of effort required to notch the dam is comparable to simply removing the entire earthfill embankment. Likewise, the stabilization costs of the remaining structure would be comparable to the costs to remove the minor amount of remaining material. Therefore, under this alternative, the DRE would remove the entire embankment dam, concrete water intakes, water supply pipes, and fish facilities at the base of the dam, with methods and equipment requirements as described for the Proposed Action.

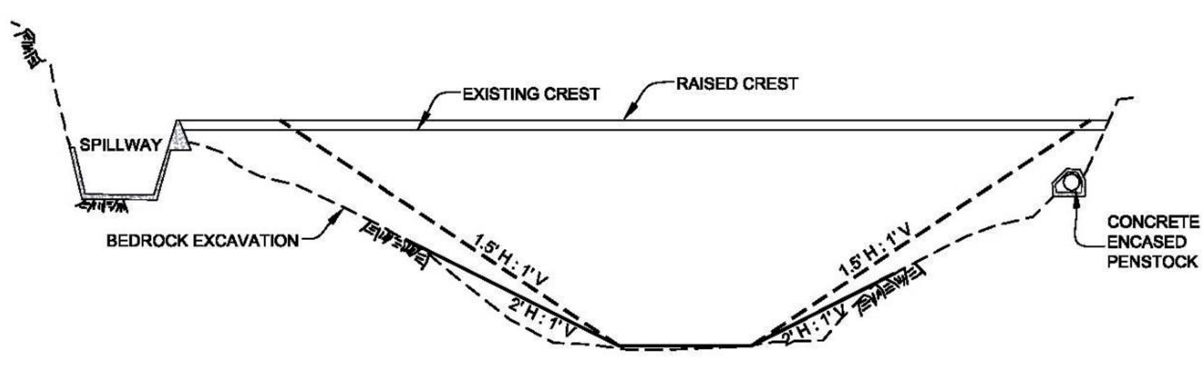

Figure 5-15. Section View of Iron Gate Dam showing 100-foot-wide Bottom Notch with Different Potential Side Slopes

Development features that would remain include the existing concrete spillway and powerhouse. The DRE would fill the spillway and chute with material removed from the dam embankment. The DRE would seal all tunnels at the upstream and downstream openings using reinforced concrete plugs to prevent unauthorized entry.

The Iron Gate fish hatchery facility downstream of the dam would remain in place. PacifiCorp would need to secure an alternate water source to replace the existing water supply pipe from Iron Gate Dam.

Retention of the Iron Gate powerhouse would require the structure to be sealed and fenced. The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the other dam removals under this alternative.

5.2.2 Schedule for the Partial Facilities Removal of Four Dams Alternative

The Partial Facilities Removal of Four Dams Alternative would follow a schedule similar to that of the Proposed Action. Figure 5-16 provides a schedule that is consistent with the schedule in Section 5.1.2 for Full Facilities Removal. The staging and methods would remain the same; however, the DRE would only remove portions of the dam and facilities. This alternative's schedule includes time to secure retained facilities by removing hazardous materials and installing fences and similar security features to prevent unwanted entry. Therefore, it is not likely that this alternative would result in a significantly shorter project schedule than the Proposed Action.

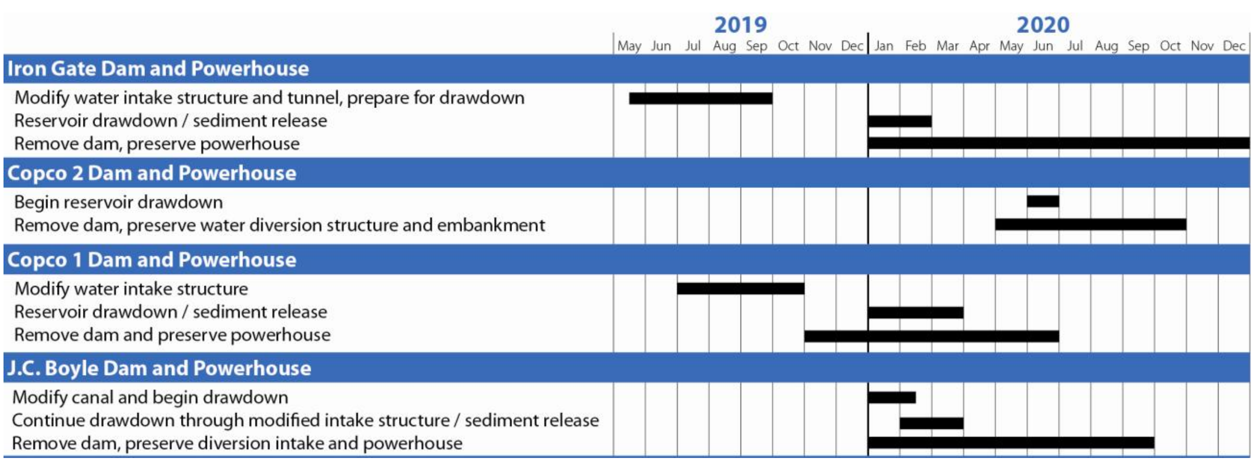

Figure 5-16. Anticipated Schedule for Partial Facilities Removal

5.2.3 Operations and Adaptive Management Actions of the Partial Facilities Removal of Four Dams Alternative

Facility operations and timing of the Partial Facilities Removal Alternative would be similar to that for the Proposed Action. Power production would decrease or cease on January 1, 2020 at

J.C. Boyle and Iron Gate Powerhouses. The DRE would prepare for partial dam removal beginning in the summer and fall of 2019 with modifications to intake structures for water control during dam removal. Embankment dam removal would begin immediately after spring runoff in June or July when conditions are safe at the Iron Gate and J.C. Boyle Dams. The winter flows would flush stored sediment in the reservoirs downstream during reservoir drawdown primarily in January and February. The DRE would stabilize remaining reservoir deposits as part of the restoration plan for each site.

As with the Proposed Action, the Partial Facilities Removal at Four Dams Alternative would require adaptive management and a monitoring plan.

5.2.4 Construction Details of the Partial Facilities Removal of Four Dams Alternative

Partial dam removal, with the objective of restoring volitional fish passage and free-flowing river conditions, is a technique that has been used with excellent success on several recent projects. Examples include the Savage Rapids Dam on the Rogue River (Oregon) and Elk Creek Dam on Elk Creek (Oregon). These dams were partially removed to restore free-flowing river conditions and fish passage at all times while leaving substantial portions of the dam and secondary structures in place. Construction techniques and overall constructability of these projects is the same as for the Proposed Action, with no specialized means or methods necessary. Because Partial Facilities Removal would be done during a one-year period, dam removal at each site would use the same equipment as the Proposed Action.

Table 5-7 shows the estimated workforce necessary for deconstruction at each facility. The crews for Copco 1 and 2 Dam removals could move between the projects as necessary to perform critical path work to reduce overall workforce numbers depending on how the contract is released for the projects. In addition to the average construction workforce, there would be 5 to 10 on-site construction management staff (e.g., inspectors, field engineers) at each site for the duration of the project.

Table 5-7. Estimated Construction Workforce for Partial Removal at each Facility

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	20 to 30 people	10 months	40–45	Jul 2020–Sep 2020
Copco 1	25 to 35 people	12 months	50–55	Nov 2019–Apr 2020
Copco 2	20 to 30 people	7 months	35–40	May 2020–Aug 2020
Iron Gate	30 to 40 people	18 months	75–80	Jun 2020–Sep 2020

The Partial Removal of Four Dams Alternative would generate different quantities of material than the Proposed Action. Table 5-8 summarizes the quantities for Partial Facilities Removal of Four Dams Alternative.

Table 5-8. Estimated Waste Quantities for the Partial Facilities Removal Alternative

Dam	Waste Material/Qty	Disposal Site	Transportation Route
J.C. Boyle	Earth - 140,000 yd^3	Right abutment site or D/S scour hole	Existing unpaved haul road - 0.5 mile
	Concrete - 8,000 yd^3	D/S scour hole	Existing unpaved canal road - up to 2.5 miles
	Metal - 700 tons	Approved landfill (Klamath Falls, OR)	Topsy Grade county road to OR Hwy 66 to US 97 - 22 miles
Copco 1	Concrete - 46,500 yd^3	Right abutment site	Improve unpaved access road - 1 mile
	Metal - 600 tons	Approved transfer station (Yreka, CA)	Copco county road to Interstate 5 - 28 miles
Copco 2	Earth - 15,000 yd^3	Right abutment site	Improve unpaved access road - 1 mile
	Concrete at dam - 4,000 yd^3	Right abutment site	Improve unpaved access road - 1 mile
	Metal - 880 tons	Approved transfer station (Yreka, CA)	Copco county road to Interstate 5 - 28 miles
	Wood-stave planks - 725 tons	Approved hazmat site	Copco county road to Interstate 5 - 120 mile
Iron Gate	Earth - 1,100,000 yd^3	Spillway and Left abutment borrow sites	Existing unpaved access roads - 1 mile
	Concrete - 10,000 yd^3	Left abutment site	Existing unpaved access roads - 1 mile
	Metal - 800 tons	Approved transfer station (Yreka, CA)	Copco county road to Interstate 5 - 24 miles

Key:
yd^3: cubic yards

5.3 Alternative 4 – Fish Passage at Four Dams

Starting in fall 2001 and continuing through 2003, PacifiCorp studied fisheries resources for the Four Facilities. The efforts served as the foundation for PacifiCorp's FERC relicensing application with regards to fisheries. The description of Alternative 4 uses information from the *United States Department of the Interior and National Marine Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis Pursuant to Section 18 and Section 33 of the Federal Power Act for the Klamath Hydroelectric Project (FERC Project No. 2082)* (DOI and NOAA Fisheries Service 2007) and from Interior's Modified Terms and Conditions and Fishways filed pursuant to Sections 4(e) and 18 of the Federal Power Action (DOI/BLM 2007). These fishway prescriptions and mandatory conditions were developed during the FERC relicensing process. Issues of Material Fact associated with the prescriptions and mandatory conditions were challenged; the resulting Administrative Law Judge decision found that the Agencies met their burden of proof on most factual issues in dispute. Attachment B includes the full set of prescriptions. The Hydropower Licensee would implement this alternative.

The prescriptions include a key condition that requires at least 40 percent of J.C. Boyle inflow to be released into the Bypass Reach. Under this alternative, the J.C. Boyle Powerhouse would produce peaking power only one day a week to coincide with recreation releases. This alternative would generate less power than current production because of the change in peaking operations and the flow requirements for the J.C. Boyle Bypass Reach. Several of the prescriptions include studies to determine if features are necessary (such as spillway and tailrace modification). For the purposes of analysis in this EIS/EIR, Alternative 4 includes some specific fishway facility design and construction details beyond what are specifically required in the prescriptions and are based on designs of similar fishway facilities used at other hydroelectric facilities.

5.3.1 General Fish Passage Facilities

Based on the prescriptions, typical upstream fish passage facilities at each dam would consist of pool and weir type fish ladders to provide the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. This type of fish ladder is generally constructed from reinforced concrete and occasionally uses metal or wood hardware for adjustable components. In order to meet the prescribed fish passage criteria (DOI and NOAA Fisheries Service 2007), the fish ladders would use 6-inch steps between each weir that would result in an overall structure slope of 4 to 6 percent. At a minimum, each ladder bay would measure 8 feet long by 6 feet wide by 5 feet deep to meet the minimum pool requirements (NOAA Fisheries Service 2008b) and thus driving the structure slope to 4 to 6 percent. Figure 5-17 shows an example of a cast-in-place pool and weir fish ladder that is similar to that proposed for upstream fish passage at the Four Facilities under this alternative. Final design of these structures would likely exceed this minimum pool dimension by 50 to 100 percent in order to meet all regulatory criteria and minimize turbulence in the ladder bays. Table 5-9 provides a minimum footprint for each upstream fish ladder.

Figure 5-17. Example of Cast-in-Place Pool and Weir Fish Ladder

Table 5-9. Minimum Structure Footprint and Dimensions for Fish Ladders at Each Dam

Dam	Vertical Drop[1] (ft)	Min. Number of Pools	Min. Structure Length (ft)	Min. Structure Footprint (ft^2)
J.C. Boyle	61	122	1,089	8,712
Copco 1	124	249	2,241	17,928
Copco 2	22	44	396	3,168
Iron Gate	157	314	2,826	22,608

Key:
ft: feet
ft^2: square feet
[1] Source: CH2M Hill 2003.

The J.C. Boyle and Copco 2 fish ladders would be well within the range of typical pool and weir fish ladders being designed today to meet fish passage criteria for the vertical drop. For instance, PacifiCorp is currently installing a pool and weir fish ladder at Soda Springs (Oregon) that has an elevation differential of approximately 57 feet with 59 pools and meets current regulatory requirements. The Copco 1 and Iron Gate fish ladders would be significantly longer and have a bigger elevation differential; however, there are two successful examples in Oregon where bigger elevation differentials have been overcome with pool and weir fish ladders for upstream fish passage. The two examples are the Faraday/North Fork ladder on the Clackamas River (196 feet tall, 1.9 miles long) and the Pelton ladder on the Deschutes River (230 feet tall, 2.8 miles long) (Ratliff et.al. 1999). The Pelton ladder was shut down in 1968 primarily due to downstream juvenile passage and not upstream passage.

Fish ladders would be designed to allow passage 90 percent of the time that migratory fish would be present in the project area. For the extreme high and low flows, or 10 percent of the time, hydraulic conditions might prevent the ladders from meeting fish passage criteria. All fish ladders would require an auxiliary water supply (AWS) to ensure adequate attraction flows at the downstream end of the ladders to draw fish into the fish ladder and to moderate water temperatures. Fishway prescriptions require two downstream entrances and associated entrance pools for each fish ladder (DOI and NOAA Fisheries Service 2007).

The AWS would consist of a pipeline or intake that draws water from the reservoir and releases it in the fish ladder and near the fishway entrance pools. General components of the AWS include a screened intake designed to NOAA Fisheries Service screening standards to prevent fish entrapment in the AWS pipeline, an automated system to control flow rates in the AWS, selective withdrawal for water temperature, and provisions to remove excess energy from the AWS prior to discharge into the fishway. The energy dissipation structures would likely be concrete structures such as stilling basins or turbines, placed close to the fishway. A series of diffusers would remove energy at the point where AWS water enters the fishway. The AWS outlet would discharge water to fishway bays upstream from the fishway entrance to provide attraction flow over a range of tailwater conditions. To accommodate increased flows, the downstream bays of the fish ladder would be larger than upstream bays in the fish ladder.

Downstream fish passage facilities at each dam would consist of V-screens with terminal fish bypass pipes. Screens would be fitted with baffle systems to help facilitate consistent velocities across the screens and provide fine-tuning and flexibility based on monitoring results. The screens would be installed on the existing hydropower water intake structures. The fish bypass system would include a feature to detect and record data for PIT-tagged downstream migrating fish. Likewise, spillways would be modified to allow safe passage of downstream migrants. Copco 1 Dam would require a surface bypass collector rather than spillway modifications due to the size of the spillway and stair-stepped spillway surface. NOAA Fisheries Service and USFWS recommended that downstream facilities be installed prior to upstream passage facilities (DOI and NOAA Fisheries Service 2007).

Table 5-10 summarizes the fish passage facilities that would be required at each dam under this alternative.

Table 5-10. Fish Passage Improvements under the Fish Passage at Four Dams Alternative

Dam	Upstream Fish Passage	Spillway Modifications[1]	Tailrace Barrier[1]	Screens & Bypass
J.C. Boyle	New fish ladder over dam with auxiliary water supply (AWS) for attraction	Spillway modification to provide smooth transition	Extend river bank and install cutoff screen	New V-screen with fish bypass
Copco 1	New fish ladder over dam with AWS	Surface bypass collector		New V-screen with fish bypass
Copco 2	New fish ladder over dam with AWS		Extend river bank and install cutoff screen	New V-screen with fish bypass
Iron Gate	New fish ladder over dam with AWS, observation and sorting station in fish ladder	Spillway modification to provide smooth transition		New V-screen with fish bypass

Notes:
1. The prescriptions require studies to determine the need for and design of spillway modifications and tailrace barriers. For the purposes of analysis in this EIS/EIR, Alternative 4 includes some specific fishway facility design and construction details that are beyond those required in the prescriptions.

The following sections provide a detailed description of necessary fish passage facilities for each dam under the Fish Passage at Four Dams Alternative.

5.3.1.1 J.C. Boyle Fish Passage Facilities

Upstream Passage

J.C. Boyle Dam has fish passage facilities, but the existing pool and weir concrete fish ladder, on the north side of the spillway, do not meet current design criteria and must be replaced because of its configuration and poor structural condition. The Fish Passage at Four Dams Alternative would include removal of the existing fish ladder structure and construction of a new pool and weir, reinforced concrete fish ladder on the north side of the dam spillway, at or near the same location as the existing fish ladder (see Figure 5-18). The overall head differential from the downstream river to the J.C. Boyle Reservoir ranges from 55 to 61 feet, depending on reservoir pool elevation. The new fish passage facilities must be designed to accommodate the reservoir pool fluctuation while maintaining continual upstream passage. The new ladder would have two entrances, to accommodate low flow and high flow conditions, at the downstream end of the ladder. The weir walls would be rounded on the edges to enhance lamprey passage.

An AWS would be necessary for temperature and attraction flow mitigation. The AWS would draw water from the reservoir through a screened inlet and variable height intake structure to provide water temperature control. The AWS would pipe water into the fish ladder at two locations and would include an energy dissipation pool to reduce turbulence.

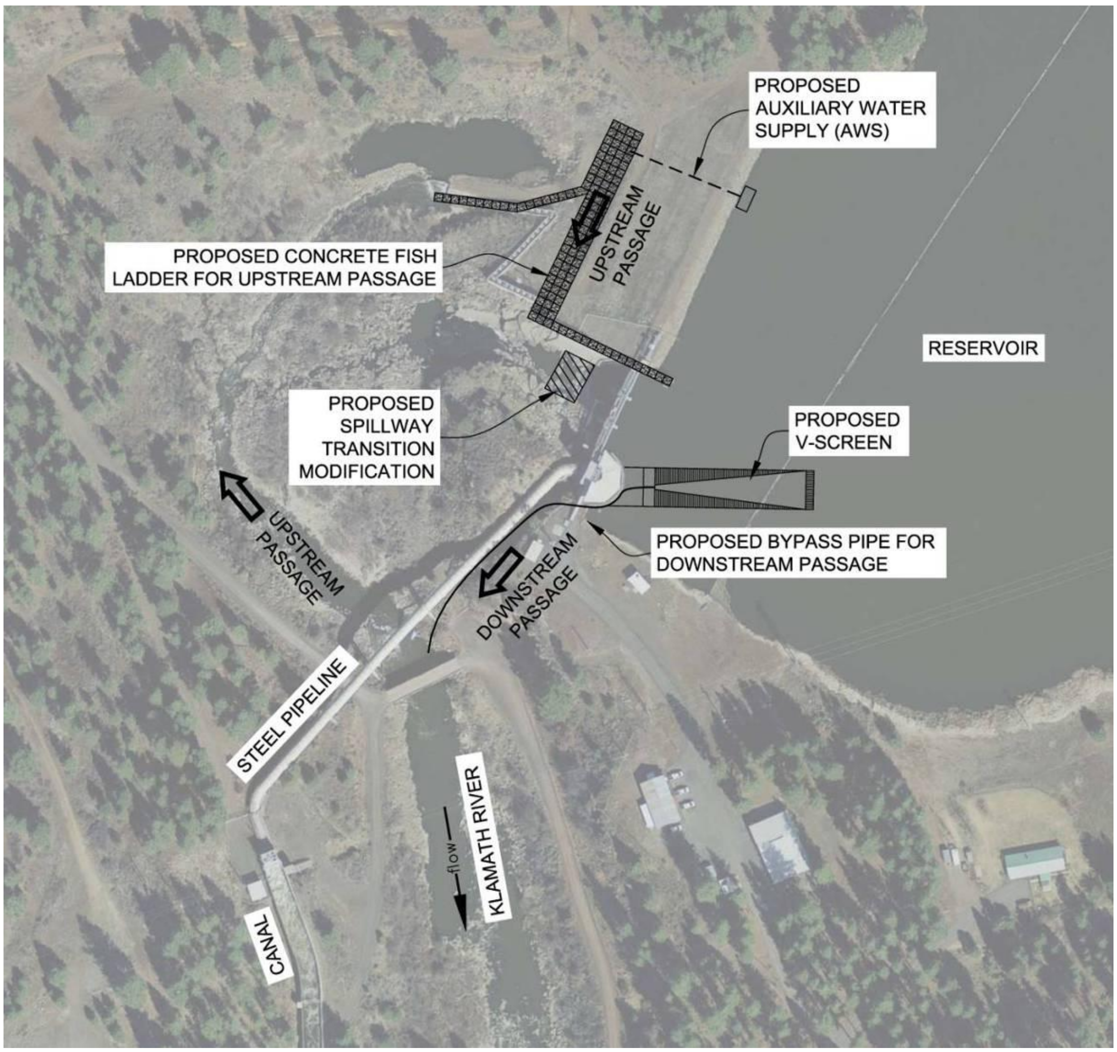

Figure 5-18. Conceptual Layout of J.C. Boyle Fish Passage Facilities

Downstream Fish Passage - Water Intake

The existing water intake has a design flow of 3,000 cfs that requires a minimum fish screen of 7,500 square feet based on an approach velocity of 0.4 feet per second. The Fish Passage at Four Dams Alternative would include a conventional V-screen at the water intake. The V-screen would terminate in a 36" diameter fish bypass pipe (approximately 40 cfs) that would run from the water intake to a bypass facility for recording downstream migrating fish and then continuing on to a controlled outfall in the river downstream of the dam. The V-screen would be stainless steel and the fish return pipe would be standard steel with concrete and steel support structures along the length of the pipe. The V-screen would have louver baffles to control the flows and ensure even velocity distribution across the screen.

Downstream Fish Passage- Spillway

Radial Tainter gates regulate discharge over the J.C. Boyle Dam's concrete spillway section which terminates in an abrupt drop onto bedrock. Modifications to the spillway would likely include building a smoother transition at the downstream end using cast-in-place concrete to form an ogee-type drop structure and minor channel modifications. This design would likely reduce fish mortality on the rock outcrop below the spillway and provide a smooth transition for downstream passage.

Tailrace Barrier

The power generation turbines for J.C. Boyle are several miles downstream from the dam with a large tailrace area that flows into the Klamath River. This tailrace has the potential for false attraction waters and needs a barrier. The Fish Passage at Four Dams Alternative would include extension of the bank of the Klamath River and installation of a stainless steel, wedge-wire cutoff screen (see Figure 5-19).

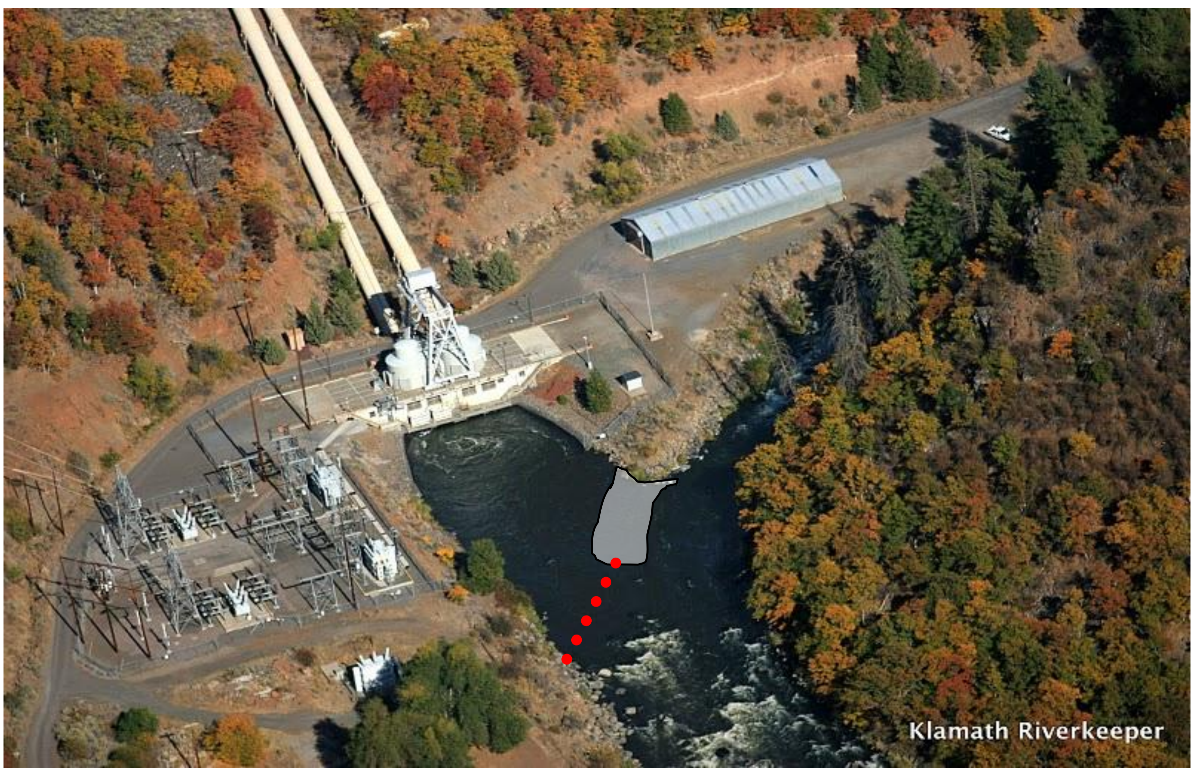

Figure 5-19. Modifications at the Tailrace of J.C. Boyle Power Generation Plant Would Extend the Bank and Install a Tailrace Barrier Screen (red dots) (photo from Klamath Riverkeeper)

5.3.1.2 Copco 1 Fish Passage Facilities

Upstream Passage

The Fish Passage at Four Dams Alternative would include a new pool and weir fish ladder on the right side of the dam for upstream fish passage. The fish ladder would have an AWS plumbed into it at two locations to moderate water temperatures, flow in the fishway, and attraction flows at the downstream end of the fishway. The downstream entrance of the fish ladder would have two entrances for low water and high water conditions, as shown in Figure 5-20.

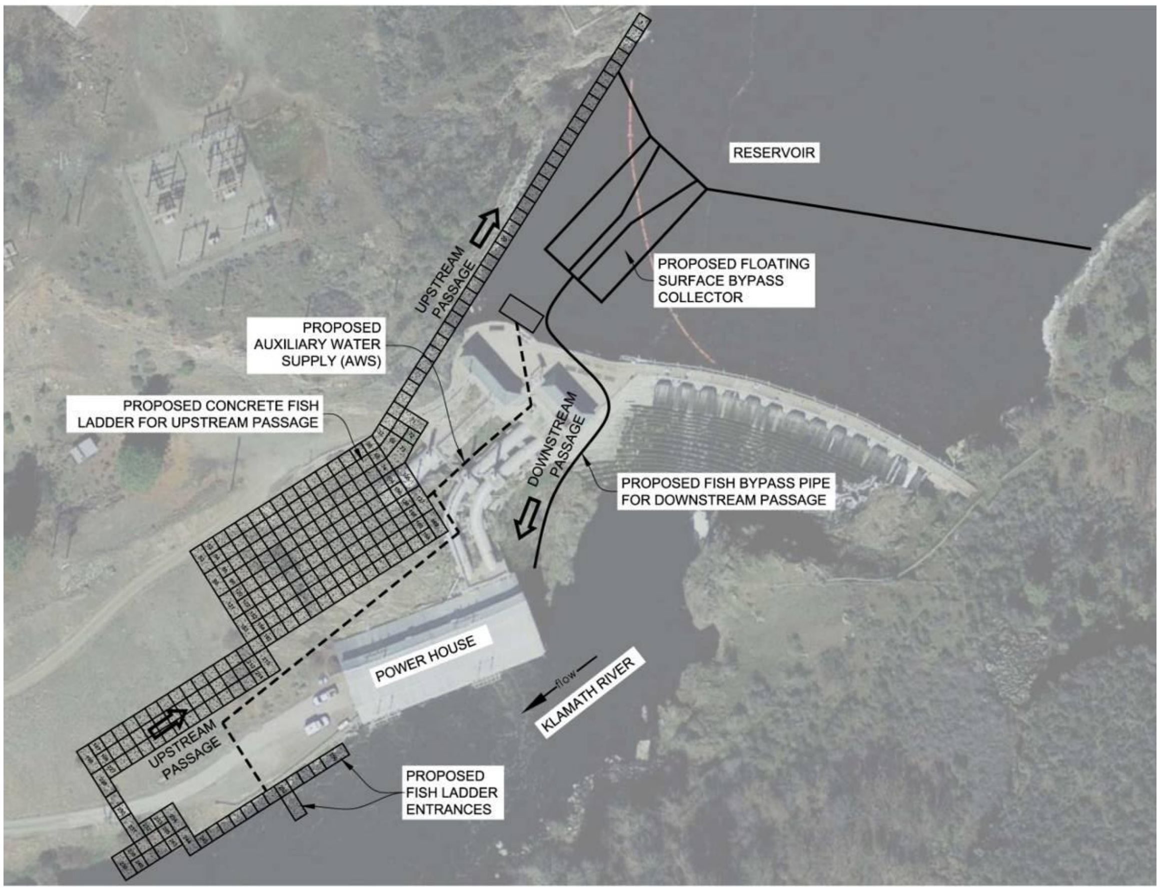

Figure 5-20. Copco 1 Fish Ladder Configuration and Floating Surface Bypass Collector

Figure 5-21 shows a recently built fish ladder at Thompson Falls Dam, Montana that is an example of what the Copco 1 fish ladder could look like when completed. The fish ladder has several shared walls built into an existing bedrock canyon wall. This example ladder also has an AWS to augment flows inside the ladder.

Figure 5-21. Example of Fish Ladder Built into Steep Bedrock Similar to Copco 1 Option (photo courtesy of GEI Consultants)

Downstream Fish Passage and Spillway Passage

The existing facilities at Copco 1 Dam are not conducive to downstream fish passage because the juvenile salmonids travelling downstream would flow through the intake to the power generation facility or over the dam spillway during high flows. Section 5.2.1 of the prescriptions (DOI and NOAA Fisheries Service 2007) states the Hydropower Licensee shall construct, operate, maintain, and evaluate a fish screen and bypass facility. To meet this requirement, the Fish Passage at Four Dams Alternative would include construction of a floating surface bypass collector (FSBC) with full depth nets to prevent fish from moving into both the water intake and the spillway. The FSBC has an integrated V-screen with a fish bypass that would screen fish away from the water intake. Several dams in the northwest have similar structures, including the Upper Baker Dam on the Baker River, Round Butte Dam on the Deschutes River, and Swift Reservoir on the Lewis River. Results from these projects have been positive and provide support for a similar system on the Copco 1 Dam.

The FSBC would be a steel structure using a typical V-screen configuration similar to Upper Baker Dam in Washington (see Figure 5-22). The existing power generation water intake has a design flow of 3,200 cfs, which requires a minimum fish screen of 8,000 square feet based on an approach velocity of 0.4 feet per second. The main FSBC would be at the intake structure on the right side of the dam. The FSBC would be anchored to the existing rock and concrete dam structure to ensure stability.

Figure 5-22. Example of Floating Surface Bypass Collector in Upper Baker Dam, Washington (photo courtesy of NOAA Fisheries Service)

Tailrace Barrier

The Copco 1 powerhouse configuration is similar to the Iron Gate facility which does not require a tailrace barrier based on observed conditions and past performance. Modified Specific Conditions (DOI and NOAA Fisheries Service 2007) Section 5.4.2 states that the Copco 1 tailrace area should be studied and a final determination should be made regarding the requirements for a tailrace barrier. Due to the similarities with Iron Gate, it is likely that a tailrace barrier will not be required and one is not included in this analysis.

5.3.1.3 Copco 2 Fish Passage Facilities

Upstream Fish Passage

The Fish Passage at Four Dams Alternative includes a concrete pool and weir fish ladder with 6-inch drops to provide volitional fish passage at Copco 2 Dam. The overall head differential from the downstream river to Copco 2 Reservoir is about 20 to 25 feet, depending on reservoir pool elevations. The new fish passage facilities would accommodate the reservoir pool fluctuation while maintaining continual upstream passage.

The pool and weir fish ladder would be on the right side of the concrete spillway structure in the earth embankment. The weir walls would be rounded concrete to enhance lamprey passage. An AWS would be necessary for temperature and attraction flow mitigation. The AWS would draw water from the reservoir through a screened inlet. Figure 5-23 shows a conceptual layout for a fish ladder at Copco 2 Dam.

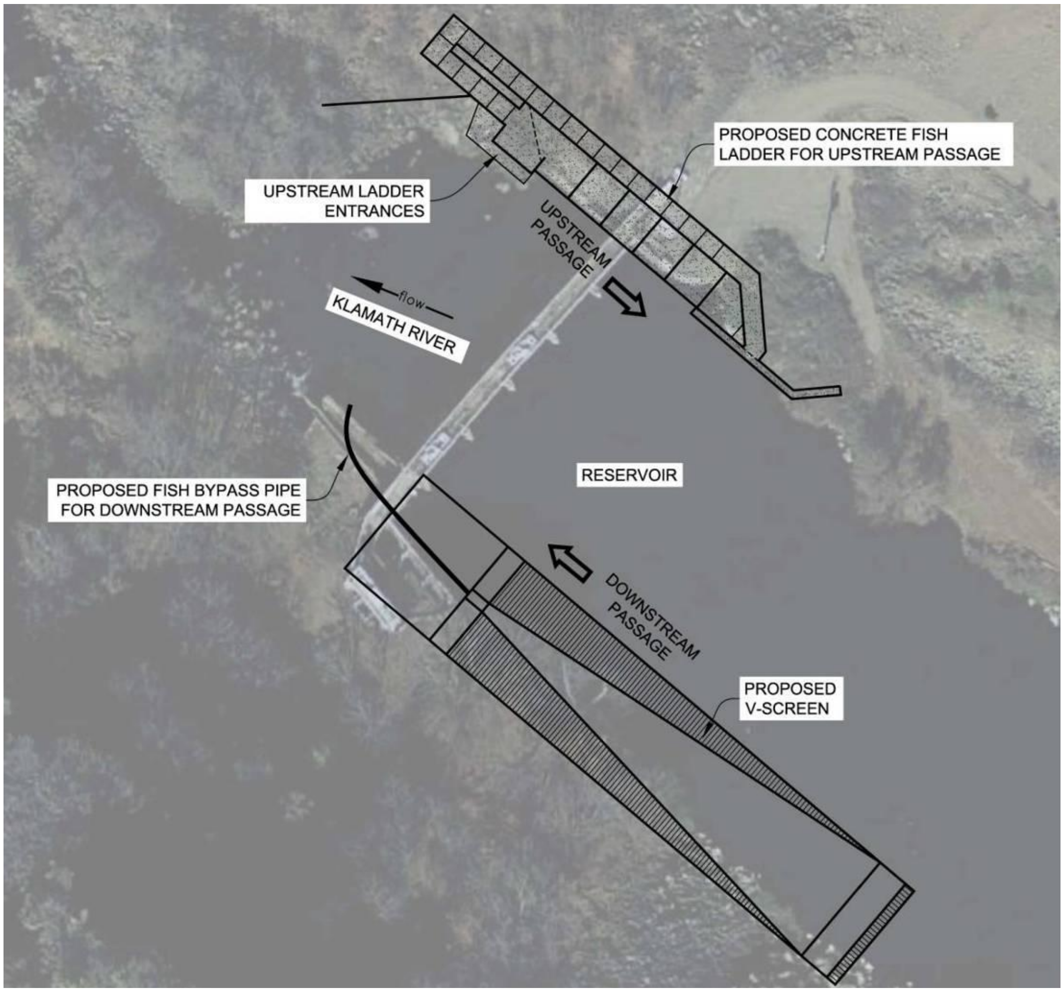

Figure 5-23. Copco 2 Fish Ladder and V-screen, along the left side of the river, for power water diversion (primarily from CH2MHill concept, 2003)

In addition to the fish ladder, a transverse bedrock sill approximately 0.5 miles upstream of the Copco 2 Powerhouse in the Bypass Reach could create a fish passage barrier. A new FERC license would likely increase flows in the Bypass Reach and this barrier would not likely exist. As part of the license renewal process, a study would determine whether corrective measures would be needed at this barrier to provide fish passage.

Downstream Fish Passage

The existing power generation water intake at Copco 2 Dam is on the left side of the concrete spillway structure. The water diversion capacity is 3,200 cfs, which would require a minimum 8,000 square feet of screen. A conventional V-screen for the water intake would minimize the length of the screen. The V-screen would terminate in a fish bypass pipe that would flow over the dam and into the downstream river area.

Tailrace Barrier

The power generation turbines for Copco 2 are several miles downstream from the dam with a large tailrace area that flows back into the Klamath River. This tailrace has the potential for false attraction waters and section 4.4.1 of the prescriptions (DOI and NOAA Fisheries Service 2007) requires a tailrace barrier unless studies prove otherwise. Due to the orientation and nature of the tailrace area, it is likely that a tailrace barrier will be required. The Fish Passage at Four Dams Alternative includes extending the bank line of the Klamath River and installing a cutoff screen to prevent fish from straying into the tailrace area (see Figure 5-24).

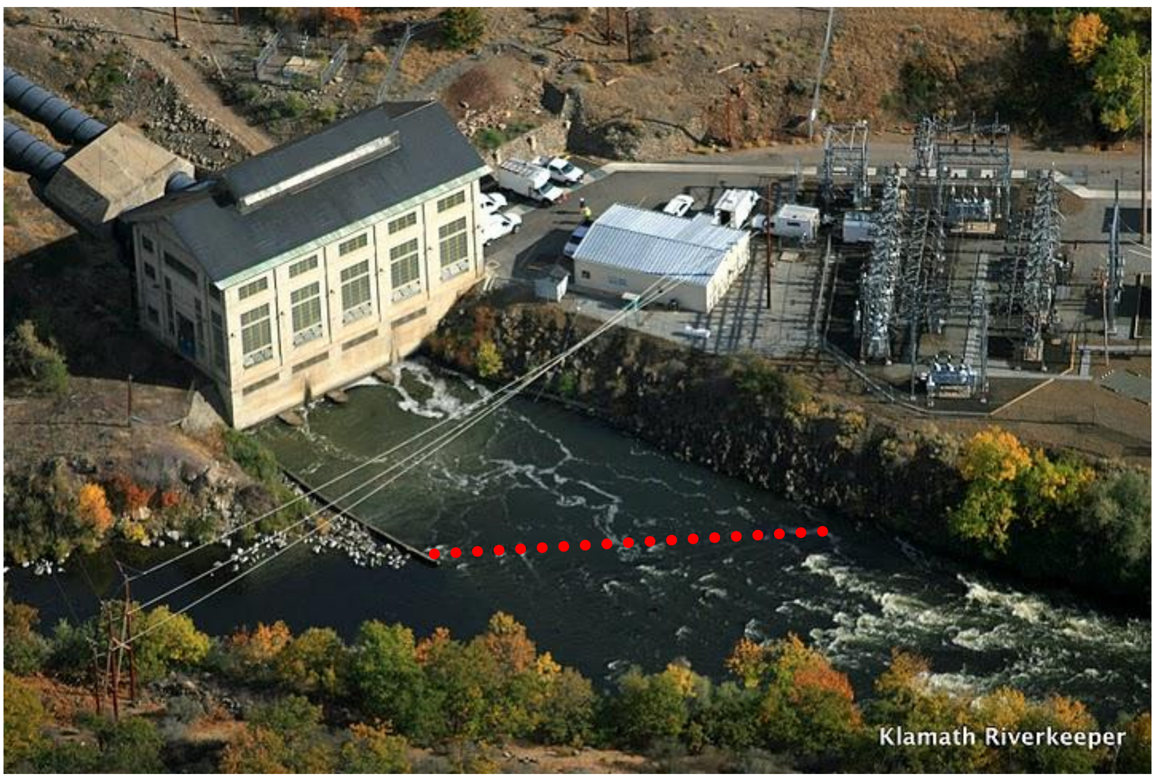

Figure 5-24. Modifications at the Tailrace of the Copco 2 Powerplant would extend the bank and install a tailrace barrier screen (red dots) (photo from Klamath Riverkeeper)

5.3.1.4 Iron Gate Dam Fish Passage Facilities

Upstream Fish Passage

The Fish Passage at Four Dams Alternative would include installation of a reinforced concrete fish ladder on the left side of the existing dam near the existing penstock pipe as shown in Figure 5-25. The fish ladder would have two entrances with entrance pools at the downstream end of the fish ladder. An AWS would feed water into the fish ladder at two locations to help with attraction flows and water temperatures.

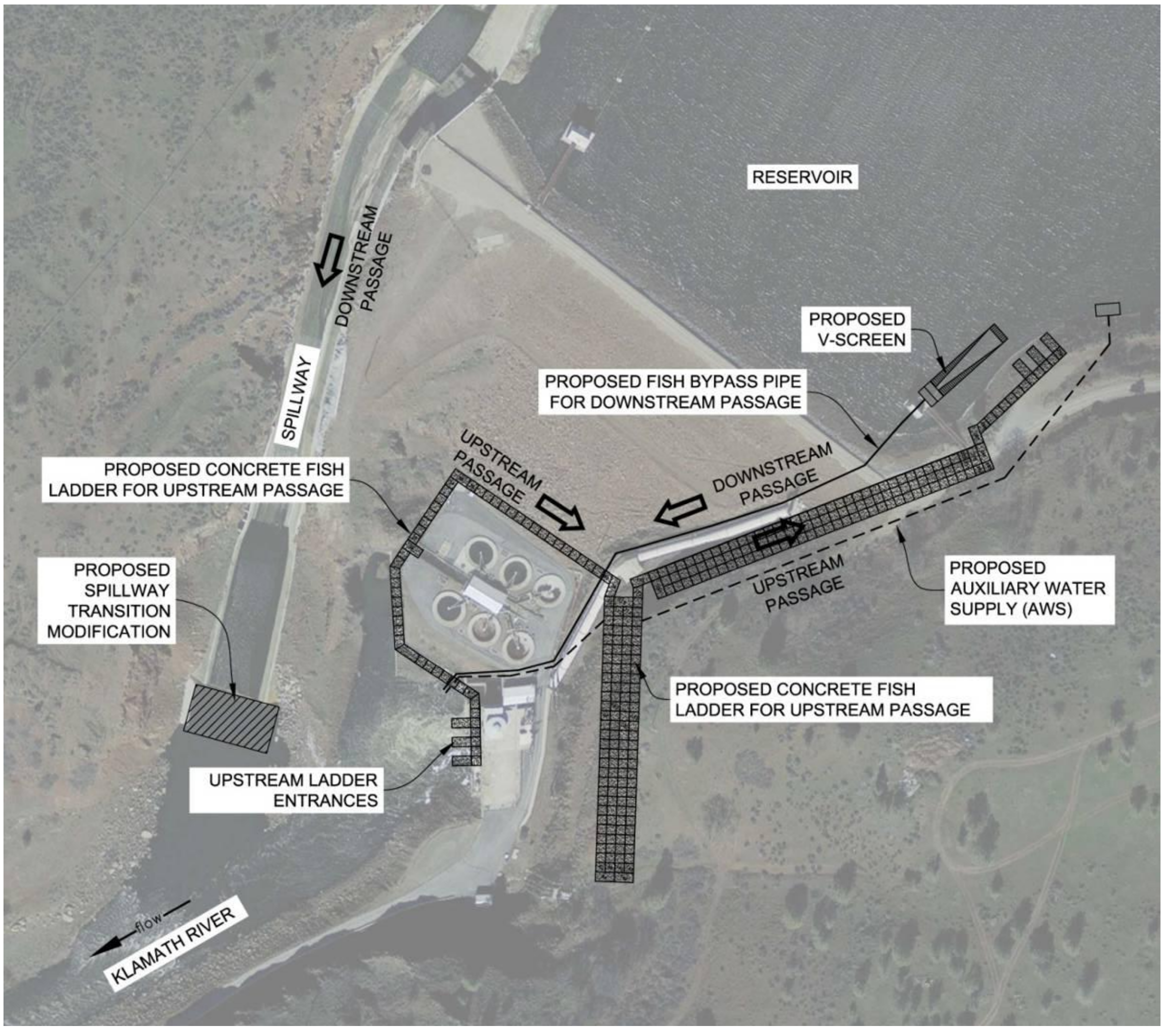

Figure 5-25. Conceptual Fish Passage Facilities Layout for Iron Gate Dam showing fish ladder, water intake screen, and spillway transition modifications

Downstream Fish Passage

The existing power generation water intake structure at Iron Gate Dam is on the left side of the embankment dam. The water intake design flow is 1,735 cfs and would require a minimum fish screen of 4,340 square feet based on an approach velocity of 0.4 feet per second. A conventional V-screen would be the best option for screening the water intake to address the substantial size of the screen. The V-screen would terminate in a 36 inch diameter fish bypass pipe (≈40 cfs) that would run from the water intake to a fish bypass facility for identification of downstream migrating juveniles and then continue downstream to the river below the dam. The V-screen would be stainless steel and the fish return pipe would be standard steel with concrete and steel support structures along the length of the pipe. The V-screen would have louver baffles to control the flows and ensure even velocity distribution across the screen.

Spillway Downstream Passage

The Iron Gate spillway is an unregulated, free overflow from the reservoir area. Likely modifications to the spillway would include building a smoother transition at the downstream end using cast-in-place concrete to form an ogee-type drop structure that would connect the downstream river levels to the free flowing spill conditions. This modification would reduce fish mortality on the rock outcrop below the spillway. In addition, the Hydropower Licensee would use concrete to fill the area just upstream of the free outfall at the downstream end of the spillway to make a consistent hydraulic transition and reduce potential harm during downstream fish passage of primarily juvenile fish.

5.3.2 Schedule for the Fish Passage at Four Dams Alternative

The schedule would likely follow the schedule prescribed in the FERC relicensing process. The prescriptions include a schedule for implementation and recommend that downstream facilities be installed prior to upstream passage facilities (DOI and NOAA Fisheries 2007). Table 5-11 shows the schedule for construction of the fish passage facilities at each dam, based on these constraints.

Table 5-11. Length of Time to Complete Fish Passage Improvements from Date of FERC License Renewal

Dam	Upstream Fish Passage	Spillway Modifications	Tailrace Barrier	Screens & Bypass
J.C. Boyle	4 years	4 years	4 years	4 years
Copco 1	6 years	6 years	N/A	6 years
Copco 2	6 years	6 years	8 years	6 years
Iron Gate	5 years	5 years	N/A	5 years

Key:
N/A: Not Applicable

5.3.3 Operations and Adaptive Management Actions of Fish Passage at Four Dams Alternative

Achieving optimal fish passage at new ladders, screens, and bypasses often requires adjustments. Fish ladders are designed to work in typical river flow ranges (i.e., between 5 and 95 percent exceedance flows) and not necessarily during extremely high and low flow conditions. At design fish passage flows, fish passage would be accessible for Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. As part of the prescriptions (DOI and NOAA Fisheries Service 2007), the Hydropower Licensee would develop a Fishway Evaluation and Modification Plan (FEMP) for review and approval by the regulatory agencies. The FEMP for fish passage facilities would describe actions to monitor and modify facilities to ensure volitional fish passage at each dam.

The FEMPs would require an annual work plan describing prospective actions the Hydropower Licensee will take to implement and monitor fish passage. Implementation of this annual work plan would ensure adequate and timely coordination between the Licensee and regulatory agencies. The annual plans also would provide insight in determining whether program goals are achieved and whether the appropriate techniques are applied for fish passage.

5.3.4 Construction Details of the Fish Passage at Four Dams Alternative

5.3.4.1 Site Access, Preparation, and Mobilization

Construction of fish ladders represents the bulk of the work under this alternative. The Hydropower Licensee would construct the ladders from reinforced concrete using construction methods typical for civil infrastructure work. Prior to beginning work, the Hydropower Licensee would make provisions to access the site, and to stage, store, and stockpile equipment and materials. Site access would require construction of temporary gravel access roads and storage pads. The Hydropower Licensee would construct access roads and storage pads with a bulldozer to clear vegetation, create level ground, and spread gravel using dump trucks to deliver crushed gravel. Preparatory work would also consist of establishing temporary power supply and offices, establishing security fencing, developing sanitary facilities for workers, creating fueling stations, mobilizing equipment, and stockpiling materials that would be incorporated into the work. The Hydropower Licensee would also install temporary sediment control provisions, with the incorporation of best management practices to minimize sediment discharge from the work site.

The J.C. Boyle site has the best access for construction equipment and staging for construction. Equipment and materials could be brought into the site on existing gravel access roads and temporary access roads where necessary. The Copco 2 site has difficult access due to the narrow canyon and relatively steep road access into the site. The existing access road would require upgrades such as gravel surfacing and grading. Like Copco 2 Dam, Iron Gate and Copco 1 Dams have difficult site access because of steep canyon terrain, and would also require special provisions, in addition to temporary roads for site access, such as a tower crane or aerial tramway for construction.

Preparatory work would also include selective demolition of existing structures to accommodate future structures or to provide work access. For concrete work, this would likely involve concrete sawing, grinding, or cutting, and/or concrete demolition. The Hydropower Licensee would remove demolished materials (rock, concrete, and steel) from the project area and dispose of them at authorized disposal sites.

The Hydropower Licensee would need to control water and isolate the work area from flowing water and aquatic organisms throughout the duration of construction. Control mechanisms would be installed prior to starting work for each dam removal. The Hydropower Licensee could control water in most areas using gravity diversions; however, pumps would be required to dewater isolated ponding. Dewatering would require electric, gasoline, or diesel powered pumps, along with flexible hosing to convey water. Pumps would discharge water away from the river into upland areas to prevent discharge of fine sediments to waterways.

The Hydropower Licensee would work in wet conditions in areas that cannot be dried. For in-water work, the Hydropower Licensee would use physical barriers of a type and in a manner similar to that used under the dam removal alternatives.

The Hydropower Licensee would need to salvage fish from work areas and prevent them from re-entering the area. The Hydropower Licensee would use specialized labor and equipment in a manner similar to that used under the dam removal alternatives.

Access and mobilization would likely require 2 weeks to 1 month for each site, depending upon the scale of the project, with the larger fish ladders at Copco 1 and Iron Gate Dams requiring additional time for access and mobilization. Grading and site preparation would scale with project size, and could be performed concurrently with access development and work area isolation. Work area isolation and de-fishing would likely take between days and two weeks depending on contractor approach, with some activities remaining concurrent on a piecemeal basis throughout construction.

5.3.4.2 Concrete Placement

The majority of work to construct the proposed fishways would consist of cast in place, reinforced concrete construction. Table 5-12 shows estimated quantities of concrete for each facility. Following grading and site preparation, the Hydropower Licensee would assemble temporary formwork and install reinforcement steel within the formwork, secured using standard ties in preparation for placing concrete. The Hydropower Licensee would construct formwork from plywood, dimensional lumber, timber,

Table 5-12. Estimated Minimum Amount of Reinforced Concrete Necessary For Fish Ladder at Each Dam

Dam	Reinforced Concrete (yd^3)
J.C. Boyle	2,800
Copco 1	5,800
Copco 2	1,000
Iron Gate	7,000

Key:
yd^3: cubic yards

and metal formwork ties. Formwork would be removed after concrete placement. A small crew of skilled workers would complete the formwork and steelwork using light equipment similar to that used for the Thompson Falls Dam fish ladder in Montana (Figure 5-26).

Figure 5-26. Typical Construction Techniques for Building Reinforced, Cast-in-Place Concrete Fish Ladder Using Lattice Crane and Temporary Access Platform at Thompson Falls Dam (photo courtesy of GEI Consultants)

Concrete placement would involve importing concrete via truck along temporary access routes, and placing concrete using pumps, booms, and hydraulic hoses for the typical access sites at J.C. Boyle and Copco 2 Dams. Concrete would be trucked from Yreka, California or Klamath Falls, Oregon. For the difficult access sites at Copco 1 and Iron Gate Dams, concrete placement would likely require a tower crane and concrete bucket or an aerial tramway and concrete bucket. The Hydropower Licensee would remove the formwork one week after concrete placement and re-use it for other work areas. The Hydropower Licensee would apply water (or concrete curing solutions) to each area for one month after concrete placement to allow the concrete to cure.

Production rates for concrete placement would likely involve placing between 40 to 80 yd^3 of concrete per day (RS Means 2008). The crew would include skilled workers for steel and formwork erection and light equipment operators for grading and material handling. Attachment A lists the typical equipment that would likely be required under this alternative.

5.3.4.3 V-Screen Installation, Tailrace Barriers and Floating Surface Bypass Collector

The V-screens intended for downstream passage and screening of power water intakes would be fabricated offsite and installed by a crew of skilled workers using light equipment. Because of the locations of the V-screens within the reservoirs, this phase of construction would require an intensive dewatering and work area isolation effort in order to provide a dry or partially isolated work area. Dewatering could require water level manipulation within the reservoir and construction of coffer barriers with pumps to dewater the work area around the water intakes.

Tailrace barriers would be constructed with cast-in-place reinforced concrete with metal screens. The area would be isolated from moving water using temporary cofferdams and dewatered with gas powered pumps. Concrete trucks would access the site and place concrete using a concrete pumping system. After construction of the tailrace barriers, the cofferdams would be removed.

The FSBC would be fabricated off-site and shipped to the site using standard flatbed trucks. The Hydropower Licensee would assemble the pieces on-site to create the larger body of the FSBC. Once the structure was assembled, the Hydropower Licensee would float it into place near the water intake area and secure it. Reservoir guide nets would facilitate fish passage through the bypass collector.

5.3.4.4 Demobilization, Clean-up, and Re-Vegetation

Following the work, the Hydropower Licensee would remove temporary facilities from the worksite, demobilize equipment, remove construction-related debris, install erosion control best management practices, and re-establish vegetation. The Hydropower Licensee would remove temporary access roads, equipment, and material staging areas. The Hydropower Licensee would loosen compacted soils in portions of the project site with soils compacted by equipment travel, grade disturbed areas, and would redistribute any stockpiled topsoil onto mineral soils. Work would likely begin at the farthest point away from improved roads and progress towards the nearest improved road.

The Hydropower Licensee would seed and mulch using a truck-mounted or aerial seed and mulch sprayer to establish grass vegetation on disturbed areas. The Hydropower Licensee would implement this erosion control practice following construction and at the end of seasonal work, should any work span seasonal work windows. The Hydropower Licensee would revegetate the site during the winter dormancy period immediately following the completion of construction. A labor crew would install plantings using hand tools and light equipment, and the intensity of the effort would scale with project size. The estimated workforce required for this alternative is summarized in Table 5-13. Each facility would also have 5 to 10 on-site construction administrative personnel (e.g., inspectors, field engineers) for the duration of the project.

Table 5-13. Estimated Average Construction Workforce for Fish Passage at Four Dams

Facility	Estimated Construction Workforce	Duration
J.C. Boyle	10 to 20 people	4 to 6 months
Copco 1	15 to 25 people	9 months
Copco 2	10 to 20 people	4 to 6 months
Iron Gate	15 to 30 people	12 months

5.4 Alternative 5 – Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

5.4.1 Features of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

This alternative consists of the full removal of Iron Gate and Copco 1 facilities and installation of upstream and downstream fish passage facilities at both the J.C. Boyle and Copco 2 Dams. On Copco 2 and J.C. Boyle Dams, ladders would be less complex to construct and provide volitional fish passage because of dam height and reservoir length. Iron Gate and Copco 1 Dams also provide less power; therefore, removal would have less effect on power generation. Removing Iron Gate and Copco 1 Reservoirs, the two largest impoundments in the Hydroelectric Reach, would also address water quality problems driven by reservoir size, such as increased water temperature, low dissolved oxygen, and toxic algal blooms in the summer and fall.

In order to meet current criteria for volitional fish passage, J.C. Boyle and Copco 2 Dams would require new upstream and downstream fish passage facilities. The fish passage facilities at J.C. Boyle and Copco 2 Dams would be the same as in the Fish Passage at Four Dams Alternative; Section 2.3.4 describes these facilities in detail. Similar to the Fish Passage at Four Dams Alternative, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would incorporate most of the prescriptions from the FERC relicensing process related to fish passage at J.C. Boyle and Copco 2 Dams (see Attachment B of Appendix A for a list of prescriptions). Alternative 5 would not incorporate the prescriptions related to peaking power at J.C. Boyle and recreation releases. In Alternative 5, Copco 2 Dam would be the only dam remaining downstream from J.C. Boyle Dam. Copco 2 Reservoir is very small, and does not have adequate capacity to reregulate flows associated with peaking operations so that they are suitable for fish downstream. Therefore, Alternative 5 would not include peaking operations or recreation releases on any days at J.C. Boyle Dam.

5.4.2 Schedule for the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

This alternative would follow a schedule similar to that of the Proposed Action, because two of the dams are being removed and fish passage would be necessary as soon as possible after dam removal. Likewise, the prescriptions require that "downstream fishways at each development should be completed prior to completion of upstream fishways at any given development." Figure 5-27 shows the schedule for construction of the fish passage facilities at two dams and for removal of the remaining two dams, based on these constraints.

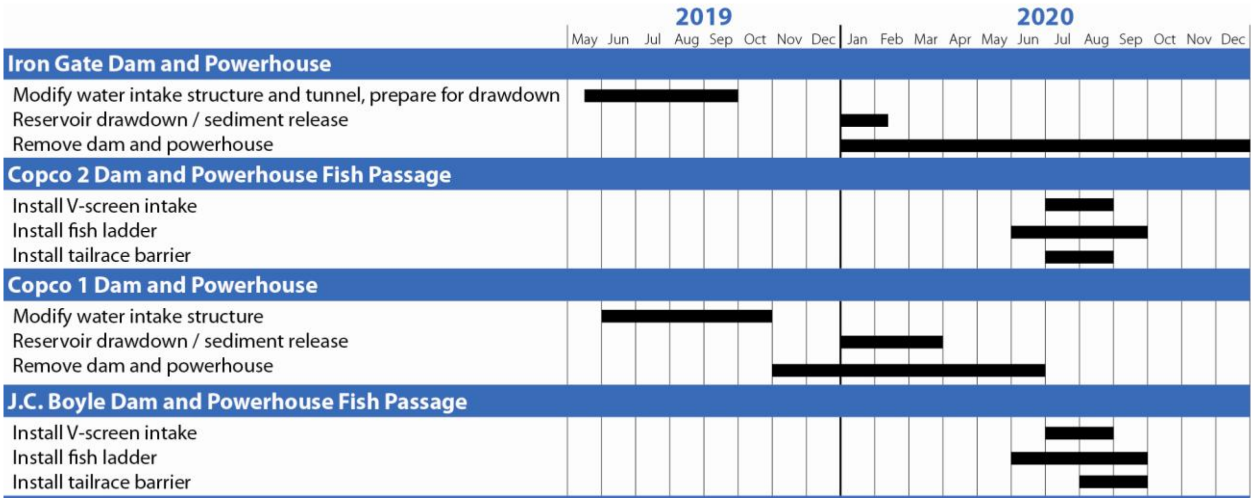

Figure 5-27. Anticipated Schedule for Full Removal of Iron Gate and Copco 1 Dams with Fish Passage at Copco 2 and J.C. Boyle Dams

5.4.3 Operations and Adaptive Management Actions of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

Adjustments are often required to achieve optimal fish passage conditions at newly installed fish ladders, screens, and bypasses. Planning, monitoring, and adaptive management actions to make the adjustments under this alternative would be as described for the Fish Passage at Four Dams Alternative (See Section 5.3.3).

Facility operations and timing of dam removal would be similar to that for the Proposed Action. The power-producing capabilities at the Iron Gate and Copco 1 Developments would be reduced or cease on January 1, 2020. Preparation for dam removal would begin in the fall of 2019 with modifications to intake structures for water control during dam removal. Section 5.1.3 describes the operations for dam removal in more detail as well as the monitoring and adaptive management requirements.

5.4.4 Construction Details of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

Table 5-14 shows the estimated workforce necessary for each facility under this alternative. In addition to the average construction workforce, there would be 5 to 10 on-site construction management staff (e.g., inspectors, field engineers) at each site for the duration of the project. The fish ladders would represent a small amount of the work under this alternative and would be constructed of reinforced, cast-in-place concrete using construction methods typical for civil infrastructure work. Section 5.3.4 presents construction details for the fish passage facilities at J.C. Boyle and Copco 2 Dams. The deconstruction efforts at Copco 1 and Iron Gate Dams would constitute the bulk of the construction efforts in this alternative. Section 5.1.4 describes construction details for dam removal at Copco 1 and Iron Gate Dams.

Table 5-14. Estimated Construction Workforce for Full Removal of Iron Gate and Copco 1 Dams with Fish Passage at Copco 2 and J.C. Boyle Dams

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	10 to 15 people	4 to 6 months	15–20	Jul 2020–Sep 2020
Copco 1	30 to 35 people	12 months	50–55	Nov 2019–Apr 2020
Copco 2	10 to 15 people	4 to 6 months	15–20	Jul 2020–Sep 2020
Iron Gate	35 to 40 people	18 months	75–80	Jun 2020–Sep 2020

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Chapter 6
Summary and Conclusions

6.1 Alternatives Evaluation

This Alternatives Report documented the process to identify initial alternatives and develop a reasonable range of alternatives for further review in the EIS/EIR. The Lead Agencies used alternatives suggested by the public and the purpose and need/project objectives statement in their initial effort to develop conceptual alternatives to achieve the desired outcome. The Lead Agencies then developed and applied a set of screening considerations to verify that the screening process was fair and unbiased when determining which alternatives should move forward for more detailed analysis. Table 6-1 shows the results of this screening process.

Table 6-1. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 1	No Action/ No Project	Implement none of the action alternatives; Klamath Hydroelectric Project would continue current operations.	Alternative 1 moved forward to the EIS/EIR for further review.
Alternative 2	Full Facilities Removal of Four Dams (Proposed Action)	Remove four dams and related facilities.	Alternative 2 moved forward to the EIS/EIR for further review.
Alternative 3	Partial Facilities Removal of Four Dams	Remove main areas of four dams to allow a free-flowing river; related facilities and/or abutments may remain.	Alternative 3 moved forward to the EIS/EIR for further review.
Alternative 4	Fish Passage at Four Dams	Construct fish passage facilities to provide upstream and downstream passage at four dams.	Alternative 4 moved forward to the EIS/EIR for further review.
Alternative 5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate	Remove Copco 1 and Iron Gate Dams, construct fish passage at J.C. Boyle and Copco 2 Dams.	Alternative 5 moved forward to the EIS/EIR for further review.
Alternative 6	Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate	Remove Copco 1, Copco 2, and Iron Gate Dams, construct upgraded fish passage at J.C. Boyle.	The EIS/EIR will fully analyze effects of removing all dams, laddering all dams, and a combination of these measures as a part of Alternatives 2, 4, and 5. The potential effects of Alternative 6 will be fully analyzed through these other alternatives. Alternative will not move forward for further analysis.

Table 6-1. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 7	Sequenced Removal of Four Dams	Sequence dam removal over three to five years.	Alternative 7 will not be carried forward for more detailed analysis in the EIS/EIR because it would not avoid or lessen environmental effects of the Proposed Action.
Alternative 8	Full Facilities removal of Four Dams without KBRA	Remove four dams and related facilities but do not implement KBRA elements.	Alternative 8 will not be carried forward for more detailed analysis in the EIS/EIR because it would not avoid or lessen environmental effects of the Proposed Action.
Alternative 9	Trap and Haul Fish	Capture fish at Iron Gate Dam and transport them upstream of J.C. Boyle Dam.	Alternative 9 will not move forward for further analysis because it does not meet the purpose and need under NEPA or most of the program objectives under CEQA.
Alternative 10	Fish Bypass: Bogus Creek Bypass	Create fish bypass using Bogus Creek, Cold Creek, Little Deer Creek, and a constructed canal to connect to Copco 1 Reservoir.	Alternative 10 will not move forward for more detailed analysis in the EIS/EIR because it does not meet any elements of the purpose and need under NEPA or program objectives under CEQA.
Alternative 11	Fish Bypass: Alternative Tunnel Route	Create fish bypass using Bogus Creek and a 5-mile tunnel to connect to Copco Reservoir.	Alternative 11 will not move forward for more detailed analysis in the EIS/EIR because it does not meet any elements of the purpose and need under NEPA or program objectives under CEQA.
Alternative 12	Notching Four Dams	Notch four dams to create a free-flowing river.	Alternative 12 is very similar to Alternative 3, and would result in the same type of impacts. Therefore, this alternative will not move forward for more detailed analysis in the EIS/EIR as a separate alternative.
Alternative 13	Federal Takeover of Project	Use authority of the Federal Power Act for government to take over dams and initiate removal.	This alternative will not move forward for more detailed analysis in the EIS/EIR because the environmental impacts would be generally the same as those under Alternative 2. This alternative would not reduce or lessen environmental effects. Moreover, the federal government has not expressed an interest in taking over the facilities.
Alternative 14	Full Removal of Five Dams	Remove Keno Dam in addition to four downstream dams.	Alternative 14 will not be carried forward for more detailed analysis in the EIS/EIR because it would not avoid or lessen environmental effects of the Proposed Action.
Alternative 15	Full Removal of Six Dams	Remove Keno and Link River Dams in addition to four downstream dams.	Alternative 15 will not be carried forward for more detailed analysis in the EIS/EIR because it would not avoid or lessen environmental effects of the Proposed Action. Implementation of Alternative 15 would also not be likely to meet Endangered Species Act requirements or tribal trust water rights within Upper Klamath Lake.
Alternative 16	Dredge Upper Klamath Lake	Remove sediments in Upper Klamath Lake to remove phosphorus and increase storage capacity.	Alternative 16 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or most of the program objectives under CEQA.
Alternative 17	Predator Control	Control seal, sea lion, and cormorant populations that are salmonid predators.	Alternative 17 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or program objectives under CEQA. Moreover, it would be difficult to permit because of biological concerns.

Table 6-1. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 18	Partition Upper Klamath Lake	Create an “inner lake” that will have lower residence time and improved water quality.	Alternative 18 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or program objectives under CEQA.

6.2 Next Steps

Five alternatives, including the No Action/No Project Alternative, were retained for further evaluation in the EIS/EIR. These alternatives represent the Proposed Action as well as other alternatives that could meet most of the purpose and need/program objectives. Several alternatives are carried forward because they represent the potential to reduce environmental effects in a resource area that could be affected by the Proposed Action. These alternatives present a range of potential actions; the Lead Agencies may decide to select (or not select) elements of these alternatives or mix elements, as long as the EIS/EIR fully analyzes these elements. The EIS/EIR will include more detailed environmental review of these alternatives.

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Chapter 7
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Attachment A. Equipment Summary

Alternative 2 - Proposed Action: Full Facilities Removal of Four Dams
Summary Estimate of Equipment Required

Equipment	J.C. Boyle	Copco No. 1	Copco No. 2	Iron Gate	Total
Lattice boom crane, 160’	1	1	1	1	**4**
Hydraulic yard crane, 40'-60'	2	2	2	2	**8**
Hydraulic excavator w/ hoe ram attachment	2	2	2	1	**7**
Hydraulic excavator, CAT 244-321 hp	2	2	2	2	**8**
Hydraulic excavator, CAT 513 hp	1	0	0	1	**2**
Wheel-loader, CAT 966, 5 yd^3	2	2	2	5	**11**
Wheel-loader, CAT 988, 8 yd^3	0	1	1	0	**2**
Dump truck, CAT 740, 20 yd^3	5	3	2	12	**22**
Crawler dozer, CAT 238	1	1	1	2	**5**
Truck-mounted seed sprayer	1	1	0	1	**3**
Pickup trucks	2	4	3	3	**12**
Flatbed truck with boom crane	1	1	0	1	**3**
Highway tractor trailer	3	1	4	1	**9**
Water tank truck, off-highway	1	1	1	1	**4**
Water tank truck, on-highway	0	1	0	0	**1**
Concrete pump truck w/ boom and hosing	1	1	1	1	**4**
Concrete trucks	2	2	2	2	**8**
Wheel-mounted asphalt paver	0	1	0	0	**1**
Vibratory compactor	0	1	0	0	**1**
Engine generator, 6.5 KW	1	1	3	1	**6**
Engine generator, 10 KW	1	1	2	1	**5**
Air compressor, 100 psi	3	2	3	2	**10**
Air compressor, 150 psi	0	1	0	0	**1**
Air-track drill, 4” hole	0	1	1	1	**3**
Pavement breaker	3	2	3	2	**10**
Acetylene torch	3	2	3	2	**10**
Submersible pump, 4-inch	3	2	5	4	**14**
Highway dump truck	0	0	0	1	**1**

Alternative 3 - Partial Facilities Removal of Four Dams
Summary Estimate of Equipment Required

Equipment	J.C. Boyle	Copco No. 1	Copco No. 2	Iron Gate	Total
Lattice boom crane, 160'	1	1	1	1	**4**
Hydraulic yard crane, 40'-60'	2	2	2	2	**8**
Hydraulic excavator w/ Hoe Ram attachment	1	2	2	1	**6**
Hydraulic excavator, CAT 244-321 hp	2	2	2	2	**8**
Hydraulic excavator, CAT 513 hp	1	0	0	1	**2**
Wheel-loader, CAT 966, 5 yd^3	2	2	2	5	**11**
Wheel-loader, CAT 988, 8 yd^3	0	1	1	0	**2**
Dump truck, CAT 740, 20 yd^3	5	3	2	12	**22**
Crawler dozer, CAT 238	1	1	1	2	**5**
Truck-mounted seed sprayer	1	1	0	1	**3**
Pickup trucks	2	4	3	3	**12**
Flatbed truck with boom crane	1	1	0	1	**3**
Highway tractor trailer	2	1	4	1	**8**
Water tank truck, off-highway	1	1	1	1	**4**
Water tank truck, on-highway	0	1	0	0	**1**
Concrete pump truck w/ boom and hosing	1	1	1	1	**4**
Concrete trucks	2	2	2	2	**8**
Wheel-mounted asphalt paver	0	1	0	0	**1**
Vibratory compactor	0	1	0	0	**1**
Engine generator, 6.5 KW	1	1	3	1	**6**
Engine generator, 10 KW	1	1	2	1	**5**
Air compressor, 100 psi	2	2	3	2	**9**
Air compressor, 150 psi	0	1	0	0	**1**
Air-track drill, 4" hole	0	1	1	1	**3**
Pavement breaker	2	2	2	2	**8**
Acetylene torch	2	2	2	2	**8**
Submersible pump, 4-inch	3	2	5	4	**14**
Highway dump truck	0	0	0	1	**1**

Alternative 4 - Fish Passage at Four Dams
Summary Estimate of Equipment Required

Equipment	J.C. Boyle	Copco No. 1	Copco No. 2	Iron Gate	Total
Lattice boom crane, 160’	1	1	1	1	**4**
Tower crane & bucket	0	1	0	1	**2**
Hydraulic yard crane, 40'-60'	2	2	2	2	**8**
Hydraulic excavator w/ hoe ram attachment	1	1	1	1	**4**
Hydraulic excavator, CAT 244-321 hp	1	1	1	1	**4**
Wheel-loader, CAT 966, 5 yd^3	1	1	1	1	**4**
Dump truck, CAT 740, 20 yd^3	2	1	2	2	**7**
Crawler dozer, CAT 238	1	1	1	1	**4**
Pickup trucks	2	3	2	3	**10**
Highway tractor trailer	1	1	1	1	**4**
Water tank truck, off-highway	1	1	1	1	**4**
Concrete pump truck w/ boom and hosing	1	1	1	1	**4**
Concrete trucks	3	6	3	4	**16**
Vibratory compactor	1	1	1	1	**4**
Engine generator, 6.5 KW	1	1	1	1	**4**
Portable generator, 1 KW	2	2	2	2	**8**
Air compressor, 100 psi	2	2	2	2	**8**
Pavement breaker	1	1	1	1	**4**
Acetylene torch	1	1	1	1	**4**
Submersible pump, 4-inch	2	2	2	2	**8**
Highway dump truck	1	1	1	1	**4**

Alternative 5 - Full Removal of Iron Gate and Copco 1 Dams with Fish Passage at Copco 2 and JC Boyle Dams
Summary Estimate of Equipment Required

Equipment	J.C. Boyle	Copco No. 1	Copco No. 2	Iron Gate	Total
Lattice boom crane, 160’	1	1	1	1	**4**
Hydraulic yard crane, 40'-60'	2	2	2	2	**8**
Hydraulic excavator w/ Hoe Ram attachment	1	2	1	1	**5**
Hydraulic excavator, CAT 244-321 hp	1	2	1	2	**6**
Hydraulic excavator, CAT 513 hp	0	0	0	1	**1**
Wheel-loader, CAT 966, 5 yd^3	1	2	1	5	**9**
Wheel-loader, CAT 988, 8 yd^3	0	1	0	0	**1**
Dump truck, CAT 740, 20 yd^3	2	3	2	12	**19**
Crawler dozer, CAT 238	1	1	1	2	**5**
Truck-mounted seed sprayer	0	1	0	1	**2**
Pickup trucks	2	4	2	3	**11**
Flatbed truck with boom crane	0	1	0	1	**2**
Highway tractor trailer	1	1	1	1	**4**
Water tank truck, off-highway	1	1	1	1	**4**
Water tank truck, on-highway	0	1	0	0	**1**
Concrete pump truck w/ boom and hosing	1	1	1	1	**4**
Concrete trucks	3	2	3	2	**10**
Wheel-mounted asphalt paver	0	1	0	0	**1**
Vibratory compactor	1	1	1	0	**3**
Engine generator, 6.5 KW	1	1	1	1	**4**
Engine generator, 10 KW	0	1	0	1	**2**
Air compressor, 100 psi	2	2	2	2	**8**
Air compressor, 150 psi	0	1	0	0	**1**
Air-track drill, 4” hole	0	1	0	1	**2**
Pavement breaker	1	2	1	2	**6**
Acetylene torch	1	2	1	2	**6**
Submersible pump, 4-inch	2	2	2	4	**10**
Highway dump truck	1	0	1	1	**3**
Tower crane and bucket	1	0	1	0	**2**
Portable generator, 1 KW	2	0	2	0	**4**

Attachment B. Department of Interior's and Department of Commerce's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082) Mandatory Conditions for Fish Passage

The following modified general prescriptions for fishways apply to each of the Services' specific prescriptions for the construction, operation, and maintenance of upstream and downstream fishways at the Project[5].

1.1.1. *Design and Construction Plans:* For each facility, the Licensee shall develop detailed design, construction, evaluation, and monitoring plans for review and approval by the Services prior to construction. All original plans, and subsequent modifications of facilities, shall be conducted according to NMFS guidelines for the design of fish screens, fishways, and other fish passage structures (National Marine Fisheries Service 1997, 2004). The Licensee, or their authorized and qualified agent(s),[6] shall have all designs reviewed by the Fisheries Technical Subcommittee (FTS) (which is to be established by the Services and comprised of engineers, biologists, and other fish passage specialists). The Licensee and its agents must establish close consultation with the Services' fisheries engineering and fish passage specialists at the outset of design and throughout the entire process. The initial design meetings shall commence at the pre-design or conceptual level design phase. Prior to advancing to feasibility-level of design, the Licensee must obtain concurrence from the Services with all preferred alternatives for each7 independent facility, or any major feature of a facility. The Licensee shall then proceed with the feasibility and final design phases providing detailed design, specification, and construction plans at the 50, 90, and 100 percent stage of completion. The Licensee shall schedule and provide a minimum of 90 days for the Services to review and approve comprehensive plans. Shorter review periods may be possible, depending on the nature of the subject, as approved by the Services. The Licensee shall implement any design modifications as required by the Services as necessary to fulfill the objective of safe, timely, and effective passage for all species considered.

1.1.2. *Access to Developments and Records*: The Licensee shall provide timely site access to the Services, CDFG, ODFW, and affected Tribes at all Klamath River Hydroelectric project developments, as well as pertinent Project records for the

[5] The following are taken from the DOI and DOC's "Modified Prescriptions for Fishways and Alternatives Analysis Pursuant to Section 18 and Section 33 of the Federal Powers Act for the Klamath Hydroelectric Project (FERC Project No. 2082), January 2007"

[6] "Authorized agents" will typically be qualified engineering and/or biological consulting firms who specialize in this area of work

purpose of inspecting fishways to determine compliance with this fishway prescription.

1.1.3. *Maintenance Requirement*: The Licensee shall keep all fishways in proper order, and shall keep all fishway areas clear of trash, sediment, logs, debris, and other material that would hinder fish passage, or create a personnel safety hazard. The Licensee shall perform anticipated maintenance well in advance of any critical migratory periods so that fishways can be tested, inspected, and be operating effectively during fish migration. If any fishway system becomes seriously damaged or inoperable, the Licensee shall notify NMFS Engineering and the Service within 48 hours. The Licensee shall take remedial action in a timely manner and in a manner satisfactory to NMFS Engineering and the Service. Fish passage facilities shall be completed, and brought on line, in a phased schedule. This will allow appropriate time and sequencing for design, contracting, construction, and in some cases, studies of the optimal design for tailrace barriers, or other facility enhancements not immediately apparent. Unless otherwise approved, downstream fishways (screens, bypasses, and spillway modifications) at each development must be complete prior to the completion of the upstream fishway at any given development. The designs approved by the Services shall be filed with the Commission.

1.1.4. *Fishway Operation, Inspection, and Maintenance Plans:* The Licensee shall, in consultation with the Services, affected Tribes, CDFG, and ODFW, develop fishway operation, inspection, and maintenance plans describing anticipated operation, inspections, maintenance, schedules, inspections, and contingencies for each fish passage facility. The operation, inspection, and maintenance plans shall be submitted to the Service and NMFS Engineering for final review at the same time as final designs for fishway construction. To minimize fish losses, the Licensee must complete these plans and ensure adequate time for review and approval by the Service and NMFS Engineering prior to the completion of construction and operation of each upstream and downstream fish passage facility. After approval by the Services, the Licensee shall file these plans with the Commission.

1.1.5. *Post Construction Fishway Evaluation Plans:* Prior to the completion of construction of the new fishways, the Licensee shall, in consultation with the Services, ODFW, CDFG, and affected Tribes, develop post-construction monitoring and evaluation plans to assess the effectiveness of each fishway, spillway, and tailrace barrier prescribed below. The plans shall include hydraulic, water quality, and biological evaluations using Passive Integrated Transponder (PIT) or similar technology to detect and record fish passage and assess the performance of the fishway, including measures for follow-up evaluations of effectiveness and fish survival through fishways. The Licensee shall provide a report to the Services on the monitoring and evaluation of the developments annually for the term of the new license.

Specifically, the plans shall include measures to estimate numbers of fish passed by species on a daily basis (including but not limited to spring-run and fall-run Chinook salmon, coho salmon, steelhead, Pacific lamprey, Lost River and shortnose suckers, and redband/rainbow trout), sampling of fish size, and the sampling of age class of fish passed at each development on a daily basis; a record of the daily observations by a qualified fisheries biologist on the physical condition of the fish using the fishways; and a continuous record of DO (dissolved oxygen) and water temperature at locations in the fishway as determined by the Services, and in front of and adjacent to the entrance(s) and exit(s) of the fishways; and an implementation schedule. The evaluation plans shall be submitted to the Services for final review and approval within six months of the date when final designs for fishway construction are approved by the Services. At least 60 days shall be provided for the Services to review the evaluation plans. The Licensee shall fund and implement the approved plans and any plan modifications, and operational or physical changes necessary for the safe, effective, and timely passage of fish as may be required by the Services. After approval by the Services, the Licensee shall file these plans with the Commission.

1.1.6 *Fishway Evaluation and Modification Plans:* The Licensee shall, in consultation with the FTS, prepare a Fishway Evaluation and Modification Plan (FEMP) for each fishway, spillway, and tailrace barrier prescribed to achieve the Services' fish passage goals and objectives. The Licensee shall provide an outline of the FEMPs to the Services no later than one year after license issuance. Consultation with the Services, CDFG, ODFW, and affected Tribes shall begin as soon as fishways are operational. The Licensee shall document all consultation, including the agencies' responses to requests for consultation, and include this documentation in the FEMPs. The complete FEMPs shall be submitted to the Services for review and approval no later than eighteen months from the date of license issuance. At least 60 days shall be provided for review. After receiving the Services' approval, the Licensee shall file the FEMPs with the Commission.

A. Each FEMP shall include:

1. A specifically quantified program to meet the Services' fish passage goals, objectives, and strategies;

2. The Services' criteria by which to measure progress towards fisheries management goals;

3. Procedures for redirecting effort, including funding, as necessary under adaptive fishway management to achieve the Services' goals and objectives;

4. A schedule for implementation of activities to achieve the Services' goals and objectives;

5. A monitoring plan to evaluate progress towards, and achievement of, the Services' goals and objectives; and

6. A format for the Annual Report and Annual Work Plan, which are described below.

B. The Services, in consultation with the ODFW, CDFG, and affected Tribes, will review the FEMPs and reserve the right to accept, reject, or modify the FEMPs, in whole or in part, to ensure the safe, timely, and effective passage of resident and anadromous fish. Any reviews or amendments to the FEMPs, over the term of the license, shall be subject to the same level of the Services' review and approval as the original FEMPs. After receiving the Services' approval, the Licensee shall file with the Commission FEMPs and any amendments therein.

C. By February 1 of every year, for the term of the License and all annual licenses, the Licensee shall submit to the Services for approval an Annual Report detailing the work accomplished under the FEMPs during the previous calendar year, progress made toward program goals and objectives, plans or suggestions to redirect effort per adaptive fishway management with a detailed justification of why this is warranted, and documentation of consultation with the Services and their responses. After receiving the Services' approval, the Licensee shall submit each Annual Report to the Commission.

D. By December 1 of every year, for the term of the License and all annual licenses, the Licensee shall submit to the Services for approval an Annual Work Plan detailing the Licensee's proposed activities for the next calendar year as necessary to implement the FEMPs. The work plan must provide sufficient detail for the Services to determine whether the Plan continues to provide for the safe, effective, and timely passage of resident and anadromous fish. The Annual Work Plan shall include, but not be limited to, detailed information on methods to be employed; schedule of activities; and explanations of how planned activities will help attain program goals. After receiving the Services' approval, the Licensee shall submit each Annual Work Plan to the Commission.

1.1.7. *Upstream Fishway Attraction Flows and Range of Design Flow*: The following general prescriptions for design flow ranges and attraction flows for fishways apply to each of the specific prescriptions below for the construction, operation, and maintenance of upstream fishways at the Project. These prescriptions are included to ensure the effectiveness of the fishways. If other mandatory license conditions or regulatory conditions require greater flows, the Licensee shall provide attraction flows and design flows consistent with those greater flows.

A. Design Streamflow Range

In consultation with the FTS and the Services and according to the terms of Modified General Prescriptions applicable to facility designs, the Licensee shall design each upstream fish passage facility to pass migrants throughout a design streamflow range, bracketed by a designated High and Low Fish Passage Design Flow, in accordance with NMFS guidelines and criteria (National Marine Fisheries Service 2004), unless site-specific analysis conducted in consultation with the Services and results approved by the Services demonstrate a more suitable flow that meets the objectives of safe, timely, and effective fish passage.

B. Project-Specific Fishway Attraction Flows

Fishway attraction flow is the total amount of flow discharged from the fishway entrance pool at any given time. The Licensee shall design, construct, operate, maintain, and evaluate physical facilities for each upstream passage facility to produce attraction flow equal to at least 10 percent of High Fish Passage Design Flow determined in accordance with NMFS guidelines and criteria (National Marine Fisheries Service 2004), as measured at a point upstream of the hydropower diversion, unless site specific analysis conducted in consultation with the Services and the results approved by the Services, demonstrate a more suitable flow that meets the objectives of safe, timely, and effective fish passage. After approval by the Services, the Licensee shall file with the Commission the results of any such site-specific analyses that demonstrate a more suitable flow that meets the objectives of safe, timely, and effective fish passage.

During facility evaluations, the Licensee may alter or balance attraction flows for testing purposes between the range of 5 percent and 10 percent, in order to determine whether fish passage efficiency can be maintained at a lower attraction flow.

C. Bypass Channel Attraction Flows and Conditions

For the Copco II and J.C. Boyle bypass channels, the Licensee shall, in consultation with the Services, design, construct, operate, maintain, and evaluate physical structures, facilities, devices or channel modifications necessary to ensure that migrating anadromous fish are consistently attracted into the bypass reach without excessive delays, unless the Services determine based on site-specific evaluations that such physical facilities or channel modifications are unnecessary. The Licensee shall conduct engineering and biological analysis in consultation with the FTS and the Services during the facility design phase for Copco II and J.C. Boyle facilities, to determine the attraction flow and hydraulic conditions at the point of confluence between the fishway bypass reach and the hydropower discharge. Based on these analyses, or other analyses of fishway effectiveness conducted under applicable prescriptions, the Licensee shall determine, in consultation with the Services, any physical facilities or channel modifications necessary to ensure that migrating anadromous fish are consistently attracted into the bypass reach without excessive delays.

Modified Specific Fishway Prescriptions for Klamath Hydroelectric Project Fishways

All modified general prescriptions above shall apply to the specific prescriptions below. The modified prescriptions for developments in the Project are summarized in Table 4.

In the Preliminary Prescriptions, the Services provided the rationale and scientific evidence providing the basis for the prescriptions. The Applicant subsequently submitted a request for hearing on disputed issues of material fact related to the preliminary prescriptions pursuant to the Federal Power Act as amended by the Energy Policy Act of 2005 (see 43 C.F.R. Part 41 and 50 C.F.R. Part 221), in which the Applicant disputed facts supporting the Services' prescriptions. After an evidentiary hearing that included direct written testimony, live cross-examination, some re-direct examination, and submission of thousands of pages of scientific studies and other evidence, the Administrative Law Judge (ALJ) in his decision made Preliminary and Ultimate Findings of Fact and Conclusions of Law, citing to the evidence submitted in the trial-type hearing process. The Modified Prescriptions incorporate by reference all of the scientific evidence cited by the Services in their preliminary prescriptions; in addition, the Services provide additional or revised discussions below in the Modified Specific Prescriptions that are based on relevant ALJ Findings, including short form citation to the relevant Findings. Where the Modified Specific Prescriptions reference the ALJ's Findings, the underlying citations to those Findings incorporate by reference supporting evidence and testimony developed in the hearing process. These citations offer further scientific support to the Services' prescriptions. These prescriptions also conform to a stipulation reached in the trial-type hearing regarding spillway modifications and tailrace barriers.

1. Iron Gate Dam

Upstream Prescription Rationale: Historically coho salmon, steelhead, and spring-run and fallrun Chinook salmon (Hamilton et al. 2005; ALJ Decision at 12, FOF 2A-3 through 2A-6) and resident trout migrated above the site of Iron Gate Dam to reach holding, spawning, incubation, and rearing habitat. Iron Gate Dam is a barrier to this passage and thus to suitable habitat in perennial streams such as Fall and Jenny Creeks (ALJ Decision at 34, FOF 6-11; ALJ Decision at 35, FOF 7-9), intermittent streams such as Camp and Scotch Creeks (ALJ Decision at 12, FOF 2A-5; ALJ Decision at 34, FOF 6-14; ALJ Decision at 35, FOF 7-9), and the main stem (ALJ Decision at 33, FOF 6-10; ALJ Decision at 35, FOF 7-9). The goal of the Services and the Klamath River Basin Fisheries Task Force is to successfully restore anadromous salmonids to their historical range and suitable habitat. A goal of the Service is to successfully restore resident fish to their historical range and suitable habitat as well. The means of reaching these goals is restoration of safe, timely, and effective fish movement. Volitional fish passage at Iron Gate Dam would be consistent with the goals and objectives of the Services and the Klamath River Basin Fisheries Task Force for resource management. These goals will be met with the provision of effective facilities, which will mitigate for the impacts of the dam. A holding, sorting, and counting facility is necessary to segregate and mark fish for management purposes. The 5 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Table 4. Summary of Modified Fishway Prescriptions and Timetable for the Klamath Hydroelectric Project (Commission Project #2082)

Development	***Target Species***	***Fish ladder and Passage Impediment Modification (In Chronological Order)***	***Tailrace Barrier[1]***	***Screens and Bypass***	***Spillway Modifications[1]***	***Interim, Seasonal Trap and Haul***
Copco 2 Bedrock Sill	Salmonids (includes Resident trout), lamprey	2 yrs (Bypass Barrier/Impediment Elimination)	Not Applicable (NA)	NA	NA	NA
J.C. Boyle (Bypass)	Salmonids, lamprey	2 yrs (Bypass Barrier/Impediment Elimination)	NA	NA	NA	NA
Eastside	Salmonids, lamprey, suckers	Reclamation current facility	3 yrs[2]	3 yrs[3] (to sucker criteria)	NA	Seasonal downstream trapping and hauling for Chinook
Westside	Salmonids, lamprey, suckers	Reclamation current facility	3 yrs[2]	3 yrs[3] (to sucker criteria)	NA	Seasonal downstream trapping and hauling for Chinook
Fall Creek	Resident trout	3 yrs (0.5 ft/drop and ≤ 10%)	5 yrs[4]	3 yrs	NA	NA
Spring Creek	Resident trout	3 yrs (0.5 ft/drop and ≤ 10% slope)	NA	3 yrs	NA	NA
Keno	Salmonids, lamprey	3 yrs (0.5 ft/drop and ≤ 10% slope)	NA	NA	3 yrs	Seasonal upstream trapping and hauling for Chinook
J.C. Boyle	Salmonids, lamprey	4 yrs (0.5 ft/drop and ≤ 10% slope)	4 yrs	4 yrs	4 yrs	NA
Iron Gate	Salmonids, lamprey	5 yrs (0.5 ft/drop and ≤ 10% slope)	NA	5 yrs	5 yrs	Modify existing trapping facility
Copco 2	Salmonids, lamprey	6 yrs (0.5 ft/drop and ≤ 10% slope)	8 yrs[4]	6 yrs	6 yrs	NA
Copco 1	Salmonids, lamprey	6 yrs (0.5 ft/drop and ≤ 10% slope)	8 yrs[4] (if adults in C2 pool)	6 yrs	6 yrs	NA

[1] As described in detail below, in accordance with a stipulation with the Applicant, the Services have revised the prescriptions for spillway modifications and tailrace barriers in the Modified Prescriptions to allow the Applicant to conduct site-specific studies on the need for and design of spillway modifications.
[2] Study of impacts to and the potential design and construction of tailrace barrier is given priority due to the presence of federally listed suckers.
[3] Screen and bypass system given priority due to the presence of federally listed suckers.
[4] Timing of Tailrace Barrier design and construction deferred for study to determine optimal design.

Benefits: Specific benefits of fishways at Iron Gate Dam include:

- Resident Trout: For the resident redband trout currently present both above and below Iron Gate Dam, fishways would restore historical seasonal movement for immature fish, restore population connectivity and genetic diversity, and allow greater utilization of existing habitat and refugial areas. Fish passage at Iron Gate Dam alone would restore the connectivity of resident redband populations in the mainstem Klamath River with those in the Copco 2 bypassed channel and Slide, Scotch, Camp, Jenny, Salt, and Fall Creeks. These tributaries also provide important habitat elements, such as spawning and temperature related refugial areas. In particular, Fall Creek provides a steady volume of high quality water and historically provided good habitat for resident fish, including rainbow/redband trout, Klamath small-scaled suckers (*Catastomus rimiculus*), and Klamath sculpin (*Cottus klamathensis*) (Coots 1957). With fish passage, seasonal migration of trout and access to refugial areas would be restored.

- Coho: Coho salmon are present in the Klamath River below Iron Gate Dam and were present historically above the dam. Iron Gate Dam blocks these fish species from reaching elements of their historical habitat. Between Iron Gate Dam and the next barrier upstream (Copco 2 Dam), access to habitat would benefit coho salmon by: a) extending the range and distribution of the species, thereby increasing the reproductive potential; b) increasing genetic diversity in the coho stocks; c) reducing the species vulnerability to the impacts of degradation; and d) increasing the abundance of the coho population (ALJ Decision at 86, Ultimate Finding of Fact 9; ALJ Decision at 36, FOF 7-16). National Research Council (National Research Council 2003) considered the amount of tributary habitat between Iron Gate Dam and the next barrier upstream to be substantial. Coho salmon were reported in Scotch Creek in 1950 (California Department of Fish and Game 2006) and are known to have spawned in Fall Creek (California Department of Water Resources 1964; Coots 1954; Coots 1957; Coots 1962). In both 1951 and 1952, at least 10 adult coho spawned in Fall Creek and greater than 29,600 young of the year and juvenile coho salmon outmigrated in 1954 (Coots 1954). Little documentation is available for Slide, Camp, and Jenny Creeks, but the lower reaches of these streams are relatively low gradient and appear to be suitable coho habitat. With fish passage, coho will likely have access to this habitat and access to refugial areas would be restored.

- Fall-run Chinook: With fish passage at Iron Gate Dam, fall-run Chinook salmon access would be restored to 11.1 miles of habitat, including Scotch, Camp, Jenny, and Fall Creeks (Table 3 of the Preliminary Prescription, hereafter referred to as Table 3) between Iron Gate Dam and the next barrier upstream (Copco 2 Dam). Prior to the construction of Iron Gate Dam, escapement of Chinook salmon to Jenny and Fall Creeks averaged 215 and 1,384 adults, respectively, from 1950 to 1960 (Coots 1957; Coots 1962; Coots and Wales 1952; Wales and Coots 1954). With fish passage, fall-run Chinook will again have access to this habitat. Seasonal migration of fall-run Chinook and access to refugial areas would be restored.

- Spring-run Chinook: With fish passage at Iron Gate Dam, spring-run Chinook salmon would regain access to cool water refugial areas necessary for this run of fish

(McCullough 1999) such as Fall Creek. Spring-run Chinook would also regain access to upstream migration corridors necessary to reach historical spawning areas in the Upper Klamath Basin (California Department of Fish and Game 1990).

- Pacific Lamprey: With fish passage at Iron Gate Dam, Pacific lamprey would gain access to habitat, including tributaries and the Copco 2 bypass reach (Table 3) between Iron Gate Dam and the next barrier upstream (Copco 2 Dam). Although the historical upstream distribution of Pacific lamprey is unknown, suitable habitat for spawning and juvenile rearing is available within tributaries and stream reaches in the Project area (ALJ Decision at 37, FOF 8-3). Access to habitat would benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the genetic diversity of the species; and d) increasing the abundance of the Pacific lamprey population (ALJ Decision at 38, FOF 8-9).

- Steelhead: With fish passage at Iron Gate Dam, steelhead would regain access to 13.7 miles of habitat, including tributaries and the Copco 2 bypass reach (Table 3), between Iron Gate Dam and the next barrier upstream (Copco 2 Dam). Adult steelhead have been documented in Fall Creek (Coots 1957, 1962). During 1951–1952, 471 steelhead spawners were counted in Fall Creek and between January and April 1954, more than 6,500 fry and 1,200 yearling steelhead emigrated from Fall Creek (Coots 1954). Steelhead have also been reported in Scotch and Camp creeks (California Department of Fish and Game 2006). Steelhead are generally tributary spawners and able to access reaches of tributaries upstream from areas where salmon spawn (Platts and Partridge 1978). Therefore, with fish passage, steelhead would have access to habitat in its entirety in tributaries above Iron Gate Dam. Steelhead would have access to 13.7 miles of habitat including Scotch, Camp, and Fall Creeks (ALJ Decision at 12, FOF 2A-5) as well as Slide and Jenny creeks. Seasonal migration of steelhead and access to refugial areas would be restored.

Downstream Prescription Rationale: Downstream fishways as modified herein are prescribed for Iron Gate Dam. Redband/rainbow trout and other resident fish (including federally listed suckers) are currently present in Iron Gate Reservoir. The Services conclude that trout (in particular fry and juveniles) move downstream (Hemmingsen 1997), a significant portion move through the powerhouse, and turbine entrainment at Iron Gate Dam causes significant mortality to downstream migrating redband trout (see discussion of turbine-caused mortality later in this paragraph). In addition, with the construction of a functional adult fish ladder at Iron Gate Dam, salmon and steelhead would return to hold, spawn, and rear in habitat where they were present historically (Hamilton et al. 2005, ALJ Decision at 12, FOF 2A-3 through 2A-6; ALJ Decision at 14, FOF 2A-12). However, the progeny of these fish must negotiate not only the reservoir but the dam, powerhouse, and spillway during their outmigration. Migration is one of several defining life history characteristics of resident trout and anadromous fish, especially salmonids (ALJ Decision at 27, FOF 3-7; ALJ Decision at 13, FOF 2A-10). To ensure that the fish can outmigrate, downstream passage through the dam, powerhouse, and spillway is necessary. Unless protected by fish screening and bypass systems, fish migrating downstream can suffer injury or death by passing through turbines at hydroelectric plants (Electric Power Research

Institute 1987). Turbine caused mortality can have serious consequences for fish populations, especially among anadromous species (Cada 2001). Survival of juvenile salmonids passing dams during their seaward migration is highest through spillways and lowest through turbines (Muir et al. 2001), turbine mortality being caused by pressure changes, cavitation, shear stress, turbulence, strike, and grinding (Cada 2001). The Electric Power Research Institute (Electric Power Research Institute 1987) reported that Francis turbines, which are used at Iron Gate Dam, had average mortality to downstream moving fish of about 24 percent. In light of the foregoing evidence, the Services conclude that turbine entrainment at Iron Gate Dam presently causes a degree of mortality to downstream migrating resident fish comparable to that cited in the studies above and would cause comparable losses of reintroduced anadromous fish populations in the future, absent effective fish screening systems. The Applicant has acknowledged, based on their initial review of other studies, that tens of thousands of resident fish are likely entrained annually at each of the unscreened mainstem Klamath River developments and estimated that between 7 to 21 percent of those fish are killed passing through the Iron Gate Powerhouse ((PacifiCorp 2004a), Exhibit E 4-113). It is estimated that “several tens of thousands of resident fish” are annually entrained at “each of the Projects” facilities (ALJ Decision at 28, FOF 4-2). It is anticipated that annual entrainment of anadromous fish would be on the same order of magnitude, if not greater. Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10 to 30 percent (ALJ Decision at 29, FOF 4-5). Volitional fish passage would be consistent with fish movement through Klamath River system for purposes such as spawning, rearing, feeding, and seasonal use of habitat, as well as ensuring that the goals and objectives of the Klamath River Basin Fishery Task Force and the Services for resource management are met. The 5 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Spillway Prescription Rationale: Spill survival estimates for salmonids are numerous and range from 76 percent to 100 percent, depending on species, life stage, amount or proportion of water spilled, spillway configuration, tailwater hydraulics, the methodology of estimating survival, and predator conditions (National Marine Fisheries Service 2000). Fish passing down a spillway may experience physical, chemical, and biological effects. Turbulent mixing of spilled water with receiving waters may result in gas supersaturation and resultant gas bubble disease in fish. Dissolved nitrogen concentrations of more than 130 percent of normal equilibrium levels have been measured in tailwaters on the Columbia River (Ebel and Raymond 1976). The threshold value for significant mortality among juvenile Chinook salmon and steelhead trout occurs when nitrogen gas levels are about 115 percent of normal. Along the Columbia River, where many spillways discharge from a given dam and there are many consecutive dams along the stream course, supersaturation increases cumulatively from one dam to the next. Losses of salmon and steelhead trout in this river due to supersaturation have been severe in years of high spillage (Ebel and Raymond 1976). Fish passing over spillways can be injured by strikes or impacts with solid objects (e.g., baffles, rocks, or walls in the plunge zone), rapid pressure changes, abrasion with the rough side of the spillway, and the shearing effects of turbulent water. Given the steepness and configuration of the Iron Gate Dam spillway, the Services conclude that spillway mortality will likely occur at levels near the high end of the range found in the studies above. Therefore, a 5 year timeline is necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific spillway prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the spillway prescriptions. The Applicant subsequently withdrew its request for hearing regarding spillway prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006-NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the spillway prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of spillway modifications for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the spillway modifications in order to inform the need for and design of spillway modifications. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that spillway modifications are necessary for the safe, timely, and effective fish passage where prescribed.

Tailrace Barrier: The Services have not prescribed the construction of tailrace barriers at Iron Gate Dam because anadromous and resident fish are currently present below the dam and the Services are aware of no reported problems with fish injury or delay during upstream migration to the hatchery.

<u>Iron Gate Dam Upstream Fishway</u>

<u>1.1 Iron Gate Dam Upstream Fishway</u>

1.1.1 *Fishway Design Features and Performance Standards*: The Licensee shall construct, operate, maintain, and evaluate a volitional fishway at Iron Gate Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS criteria for anadromous fish (National Marine Fisheries Service 2004) or alternative criteria for other species approved by the Services. The ladder shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The ladder shall have a minimum of two entrances and associated entrance pools. An auxiliary water system (AWS) shall be designed to augment ladder flow from the forebay, or a suitable alternative source. The AWS shall be screened in accordance with NMFS juvenile fish screen and bypass criteria (National Marine Fisheries Service 1997) or such alternative criteria as may be determined acceptable to the Services. The AWS shall be designed to provide the suitable water quality and quantity to effectively attract fish. The fish ladder and AWS together must be designed to supply attraction flows according to the terms of Modified General Prescriptions 1.1.7. The ladder shall have a maximum drop between pools of 0.5 ft and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1 in

Preliminary Prescription herein referred to as Table 1). The ladder shall include features to detect and record data for PIT-tagged (or fish identified using similar technology) upstream migrating fish. The construction shall include features to modify the existing development to hold, count, and mark fish and to sort fish by age, species, and origin for the purposes of fish population restoration and management. The upstream fishway shall be constructed to current criteria for passage of Pacific lamprey and the existing ladder to the CDFG trap and holding tanks shall be modified to current criteria (Table 1) for lamprey passage and resident trout passage. The Licensee shall complete construction and begin operation of the fishway within 5 years of the issuance of the new license.

1.1.2 *Design Consultation*: The ladder design shall include features to detect and record data for PIT-tagged upstream migrating fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of Modified General Prescriptions 1.1.1 above within 2 years of the issuance of a new license for review and approval by the Services prior to construction. The design shall include features to modify the existing development to hold, count, and mark fish; and to sort fish by age, species, and origin for the purposes of fish population restoration and management.

1.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

<u>1.2 Iron Gate Dam Downstream Fishway</u>

1.2.1 *Intake Fish Screens and Bypass Facilities*: The Licensee shall, to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout, construct, operate, maintain, and evaluate a fish screen and bypass facility for volitional fish passage at Iron Gate Dam. The screens and bypass shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen criteria (National Marine Fisheries Service 1997) or alternative criteria as determined by the Service and NMFS Engineering. The screens and bypass shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The bypass facility shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall complete construction and begin operation of the fishway within 5 years of the issuance of the new license.

1.2.2 *Design Consultation*: The bypass facility design shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 2 years of the issuance of the new license for review and approval by the Service and NMFS prior to construction.

1.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

1.3 Iron Gate Spillway

1.3.1 *Spillway Modification*: Unless the Services determine based on site specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 1.3.2 and 1.3.3, the Licensee shall modify, maintain, and evaluate hydraulically-engineered spillway modifications to improve volitional downstream fish passage at Iron Gate Dam for Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The purpose of all spillway modifications is to improve hydraulic conditions and overall fish passage conditions on the downstream side of the dam, to prevent false attraction to non-passable areas, and to make the entrance of the fishway more accessible. The spillway modifications shall be constructed and operational within 5 years of the issuance of the new license.

1.3.2 *Spillway Modification Studies*: The Licensee may, in consultation with the Services, study the need for and design of hydraulically-engineered spillway modifications to improve volitional downstream fish passage at Iron Gate Dam for Chinook and coho salmon, steelhead trout, Pacific Lamprey, and redband trout. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of spillway modifications for review and approval by the Services consistent with the provisions for timing of the spillway design consultation under Modified Specific Prescriptions 1.3.3.

1.3.3 *Spillway Design Consultation:* Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 1.3.2, within 3 years of the issuance of the new license, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above for review and approval by the Service and NMFS Engineering.

1.3.4 *Spillway Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

2. Fall Creek Diversion Dam

The prescriptions for fishways at the Fall Creek Diversion Dam are made solely by the Service. The prescription for the Fall Creek Powerhouse Tailrace Barrier is made jointly by NMFS and the Service.

Upstream Prescription Rationale: There are currently no upstream fish passage facilities at the Fall Creek Diversion Dam for any species ((PacifiCorp 2004b) Fish Resources FTR). This dam is a seasonal or low flow barrier to the upstream movement of fish (Scott Snedaker, BLM pers. comm.). The Applicant has proposed an upstream fishway at this development. The Service's prescription is consistent with this proposal. Redband/rainbow trout are present in Fall Creek below the dam and above the dam. The fish need to be able to move between the two areas to make seasonal use of habitat. Volitional upstream passage would be consistent with the Service goal to successfully restore resident fish to their historical range. One objective of reaching this goal is the restoration of safe, timely, and effective fish movement, and to ensure the Project does not impair future restoration of fish populations in the upper Fall Creek and Klamath River systems. The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Downstream Prescription Rationale: There are currently no downstream fish passage facilities at the Fall Creek Diversion Dam for any species ((PacifiCorp 2004b) Fish Resources FTR, Exhibit E). The Applicant has proposed a downstream fish screen (but no bypass) at this development. We agree with the Applicant's proposal to screen downstream migrating fish. In addition, a bypass system is needed to guide the movement of redband/rainbow trout and restore historical fish populations in Fall Creek. Redband trout are present above the diversion. The Services conclude that trout (in particular fry and juveniles) move downstream here as they do in the Klamath River system elsewhere (Hemmingsen 1997), a significant portion move through the diversion canal, and that turbine entrainment at the Fall Creek Powerhouse causes significant mortality to downstream migrating redband trout (see the discussion for the Downstream Prescription Rationale for the Iron Gate Dam development). With the 5 cfs proposed for instream flows by the Applicant and the construction of a functional fish ladder at the Fall Creek Diversion Dam, biological connectivity for rainbow trout would be restored to some degree in upper Fall Creek. However, the progeny of these fish must be excluded from the power canal and turbines. Adequate passage conditions would be consistent with the Service's goal of restored fish populations in the Fall Creek system. The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Fall Creek Powerhouse Tailrace Prescription Rationale: With an upstream fishway at Iron Gate Dam, anadromous fish would migrate to Fall Creek to the powerhouse. Coots (1954; 1957; 1962) reported steelhead, coho, and Chinook salmon in Fall Creek downstream from the powerhouse. Depending on powerhouse operations, draft tube discharge velocities at Project facilities are between 3.4 and 10.4 feet per second (fps) (CH2MHill 2006); these velocities easily fall within the swimming abilities of salmonids (Weaver 1963). The types of injury sustained by some fish entering draft tubes or contacting turbines vary from site to site, as do immediate and delayed mortality rates. Several studies, however, attribute injuries in migrating salmonids to powerhouse structures associated with tailrace structures (Department of Fisheries Canada 1958; International Pacific Salmon Fisheries Commission 1976; Schadt et al. 1985; Williams 1985). To prevent injury or mortality to salmonids caused by attempts to swim upstream into the tailrace, a barrier is required to prevent fish from entering this area (National Marine Fisheries Service 2004). The 5 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific tailrace barrier prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the tailrace barrier prescriptions. The Applicant subsequently withdrew its request for hearing regarding tailrace barrier prescriptions based on a stipulation with the Services (In the Matter Of: *Klamath Hydroelectric Project*, Docket Number 2006-NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the tailrace barrier prescriptions in the Modified Prescriptions below to allow time for the Applicant to study the need for and design of tailrace barriers for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the tailrace barriers in order to inform the need for and design of tailrace barriers. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that tailrace barriers are necessary for the safe, timely and effective upstream passage of fish at Fall Creek Diversion Dam.

2.1 Fall Creek Diversion Dam Upstream Fishway

2.1.1 *Fall Creek Upstream Fishway*: The Licensee shall construct, operate, maintain, and evaluate a volitional upstream fishway at the Fall Creek Diversion Dam to provide for the safe, timely, and effective upstream passage of rainbow/redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS criteria (National Marine Fisheries Service 2004) or alternative criteria as determined by the Service. The ladder shall provide for the uninterrupted passage of fish over the full range of Fall Creek flows. The ladder shall have a maximum drop between pools of 0.5 ft and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1). The fishway shall be constructed and operational within 3 years of the issuance of the new license.

2.1.2 *Design Consultation*: The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 1 year of license issuance for review and approval by the Service prior to construction.

2.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

2.2 Fall Creek Diversion Dam Downstream Fishway

2.2.1 *Intake Fish Screens and Bypass Facility*: The Licensee shall construct, operate, maintain, and evaluate a fish screen and bypass facility at the Fall Creek Diversion Dam to provide for the safe, timely, and effective downstream passage of rainbow/redband trout. The screens and bypass facility shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen and bypass facility criteria (National Marine Fisheries Service 1997) or alternative criteria as determined by the Service. The screens and bypass facility shall provide for the uninterrupted passage of fish over the full range of river flows. The downstream fishway shall be constructed and operational within 3 years of the issuance of the new license.

2.2.2 *Design Consultation*: The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above, within 1 year of the issuance of the new license, for review and approval by the Service prior to construction.

2.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

2.3 Fall Creek Powerhouse Tailrace Barrier

2.3.1 *Tailrace Barrier Construction*: Unless the Services determine, based on site-specific studies, that a tailrace barrier is unnecessary in accordance with Modified Specific Prescriptions 2.3.2 and 2.3.3, the Licensee shall construct a tailrace barrier and guidance system at Fall Creek Powerhouse to provide for the safe and effective protection and guidance of Chinook salmon, coho salmon, steelhead, and redband trout away from the powerhouse. The tailrace barrier and guidance system shall be constructed according to approved design plans and within 5 years of the issuance of the new license.

2.3.2 *Tailrace Barrier Studies*: The Licensee may, in consultation with the Services, study the need for and design of tailrace barriers to protect upstream migrating Chinook salmon, coho salmon, steelhead, and redband trout at the Fall Creek Powerhouse. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of tailrace barriers for review and approval by the Services consistent with the provisions for timing of the tailrace barrier design under Modified Specific Prescriptions 2.3.3

2.3.3 *Tailrace Barrier Design*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 2.3.2, the Licensee shall, within 3 years of the issuance of the new license, develop detailed design and construction plans for Service and NMFS Engineering approval for a tailrace barrier and guidance system to protect adult fish according to the terms of the Modified General Prescriptions 1.1.1 above.

2.3.4 *Tailrace Barrier Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

3. Spring Creek Diversion Dam

The prescriptions for fishways at the Spring Creek Diversion Dam are made solely by the Service.

Upstream Prescription Rationale: There are currently no upstream fish passage facilities at the Spring Creek Diversion Dam for any species ((PacifiCorp 2004b) Fish Resources FTR). The Applicant has proposed an upstream fishway at this development. We agree with this action and our prescription is consistent with the Applicant's proposal. Redband/rainbow trout are present in Spring Creek below the dam and above the dam. The fish need to be able to move between the two areas to make seasonal use of habitat. Volitional upstream passage would be consistent with the Service goal to successfully restore resident fish to their historical range. The objective in reaching these goals is the restoration of safe, timely, and effective fish movement, and to ensure the Project does not impair future restoration of fish populations in the upper Spring Creek, Jenny Creek, and Klamath River systems. The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Downstream Prescription Rationale: There are currently no downstream fish passage facilities at the Spring Creek Diversion Dam for any species ((PacifiCorp 2004b) Fish Resources FTR). The Applicant has proposed a downstream fish screen at this development. We agree with the Applicant's proposal to screen downstream migrating fish. In addition, a bypass system is needed to guide the movement of redband/rainbow trout and restore historical fish populations in Spring Creek. The Service concludes that trout (in particular fry and juveniles) move downstream here as they do in the Klamath River elsewhere (Hemmingsen 1997), a significant portion move through the Spring Creek diversion canal to Fall Creek, and turbine entrainment at the Fall Creek Powerhouse causes significant mortality to redband/rainbow trout that have originated in Spring Creek (see the discussion for the Downstream Prescription Rationale for the Iron Gate Dam development). Volitional fish passage to a bypass around the Spring Creek Diversion Dam is consistent with the Service goals and objectives for resource management. With minimum flows and the construction of a functional fish ladder at the Spring Creek

Diversion Dam, biological connectivity for rainbow trout would be restored to some degree in Spring Creek. However, these fish must be excluded from the power canal and turbines. Adequate passage conditions would be consistent with the Service's goal of restored fish populations in the Spring Creek system. The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

3.1 Spring Creek Diversion Dam Upstream Fishway

3.1.1 *Spring Creek Upstream Fishway*: The Licensee shall construct, operate, maintain, and evaluate a volitional fishway at Spring Creek Diversion Dam to provide for the safe, timely, and effective upstream passage of rainbow/redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS criteria (National Marine Fisheries Service 2004) or alternative criteria as determined by the Service. The ladder shall provide for the uninterrupted passage of fish over the full range of Spring Creek flows. The ladder shall have a maximum drop between pools of 0.5 ft (Table 1) and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1). The fishway shall be constructed and operational within 3 years of the issuance of the new license.

3.1.2 *Design Consultation*: The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 1 year of the issuance of the new license for review and approval by the Service prior to construction.

3.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

3.2 Spring Creek Diversion Dam Downstream Fishway

3.2.1 *Intake Fish Screens and Bypass Facility*: The Licensee shall construct, operate, maintain, and evaluate a fish screen and bypass facility at the Spring Creek Diversion Dam to provide for the safe, timely, and effective downstream passage of rainbow/redband trout. The screen and bypass facility shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen and bypass facility criteria (National Marine Fisheries Service 1997) or alternative criteria as determined by the Service. The screens and bypass facility shall provide for the uninterrupted passage of fish over the full range of river flows. The downstream fishway shall be constructed and operational within 3 years of the issuance of the new license.

3.2.2 *Design Consultation*: The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1

above within 1 year of the issuance of the new license for review and approval by the Service prior to construction.

3.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

4. Copco 2 and Copco 1 Dams

Copco 2 and Copco 1 Upstream Prescription Rationale: Historically coho salmon, steelhead, and spring-run and fall-run Chinook salmon (Hamilton et al. 2005; ALJ Decision at 12, FOF 2A-3 through 2A-6) and resident trout migrated above the site of Copco 2 and Copco 1 dams to reach holding, spawning, incubation, and rearing habitat. Copco Dams are a barrier to this passage and thus to suitable habitat in Shovel Creek, a perennial stream (ALJ Decision at 34, FOF 6-11; ALJ Decision at 35, FOF 7-9), intermittent streams such as Beaver and Deer Creeks (ALJ Decision at 34, FOF 6-14; ALJ Decision at 35, FOF 7-9), habitat areas cooled by springs (thermal refugia) in the J.C. Boyle bypass (ALJ Decision at 33, FOF 6-10), and the main stem (ALJ Decision at 33, FOF 6-10; ALJ Decision at 35, FOF 7-9). The goal of the Services and the Klamath River Basin Fisheries Task Force is to successfully restore corresponding life history phases of anadromous salmonids to their historical range and to this suitable habitat. The Service goal is to successfully restore resident fish to their historical range and suitable habitat as well. The objective in reaching these goals is restoration of safe, timely, and effective fish movement through volitional fish passage. Providing volitional fish passage at Copco 2 and Copco 1 Dams is consistent with goals and objectives for resource management of the Services and the Klamath River Basin Fisheries Task Force. The 6–8 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Benefits – The Copco Dams are less than one half mile apart. Specific benefits of fishways at Copco 2 and Copco 1 Dams include:

- Resident Trout: For the resident redband/rainbow trout currently present both above and below Copco 2 and 1 Dams, fishways would restore historical seasonal migration patterns for immature fish, restore population connectivity and genetic diversity, and allow greater utilization of existing habitat and refugial areas. For resident rainbow/redband populations, fish passage at the Copco Dams alone would result in restoring the connectivity of fish populations in the mainstem Klamath River below the Copco Dams with those in tributaries above the dams and the Klamath River reach designated as Wild Trout water by the CDFG (California Department of Fish and Game 2005). The lower 2.7 miles of Shovel Creek are accessible and provide important habitat elements for rainbow/redband trout, including spawning and temperature related refugial areas. With fish passage, Shovel Creek would again become accessible to resident trout from below the Copco Dams and seasonal migration and habitat use would be restored.

- Coho: Coho salmon are present in the Klamath River below Iron Gate Dam and were present historically below and above Copco 2 and Copco 1 Dams. Copco 2 and

Copco 1 Dams block these fish from reaching elements of their historical habitat. Access to habitat within the Project would benefit coho salmon by: a) extending the range and distribution of the species thereby increasing the reproductive potential; b) increasing genetic diversity in the coho stocks; c) reducing the species vulnerability to the impacts of degradation; and d) increasing the abundance (ALJ Decision at 86, Ultimate Finding of Fact 9; ALJ Decision at 36, FOF 7-16). Between Copco 1 and Copco 2 Dams and the next barrier upstream (J.C. Boyle Dam), coho salmon would have access to suitable habitat, including the J.C Boyle peaking and bypass reaches of the Klamath River mainstem (Table 3; ALJ Decision at 35, FOF 7-9). With fish passage, coho would have access to this habitat again and connectivity to refugial areas would be restored.

- Spring-run Chinook: With passage, spring-run Chinook salmon access to cool water refugial areas such as the 220 cfs of spring water in the J.C. Boyle bypassed reach would be restored. During summer months, this would provide key holding, coolwater refugial habitat necessary for this run of fish (McCullough 1999). Juvenile spring-run Chinook would be able to rear in the cool water habitat adjacent to the springs in the J.C. Boyle bypass reach. These springs also provide warmer, ice-free habitat during winter months (Hanel and Gerlach 1964). The temperature of incoming spring water does not vary substantially from 50 to 55°F throughout the year (USDI Bureau of Land Management 2003) and would be optimal for juvenile Chinook growth (McCullough 1999). Springrun Chinook adults would also have access to the main channel as an upstream migration corridor necessary to reach historical spawning areas in the Upper Klamath Basin (California Department of Fish and Game 1990).

- Fall-run Chinook: Between Copco 2 and Copco 1 Dams and the next barrier upstream (J.C. Boyle Dam), passage for fall-run Chinook salmon would restore access to 25.8 miles of habitat, including the J.C Boyle peaking and bypass reaches of the Klamath River mainstem (Table 3; ALJ Decision at 33, FOF 6-10; ALJ Decision at 34, FOF 6-11; ALJ Decision at 34, FOF 6-14 and ALJ Decision at 86, Ultimate Finding of Fact 8). Snyder (Snyder 1931) reported large numbers of salmon annually passed the point where the Copco Dams are now located. The lower 2.7 miles of Shovel Creek continue to provide good salmonid habitat. The reach of the Klamath River between Copco 1 Reservoir and the Oregon/California State line is designated Wild Trout water and is currently managed under the Wild Trout Program by the CDFG (California Department of Fish and Game 2005). With fish passage, this area would again become accessible to fall-run Chinook salmon.

- Pacific Lamprey: Between Copco 2 and Copco 1 Dams and the next barrier upstream (J.C. Boyle Dam), passage would allow access to habitat, including tributaries and the mainstem Klamath River (Table 3). This access to habitat would benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the genetic diversity of the species; and d) increasing the abundance of the Pacific lamprey population (ALJ Decision at 38, FOF 8-9).

- Steelhead: Between Copco 2 and Copco 1 Dams and the next barrier upstream (J.C. Boyle Dam), passage would allow steelhead to regain access to 27.1 miles of habitat, including the J.C Boyle peaking and bypass reaches of the Klamath River mainstem (Table 3; ALJ Decision at 33, FOF 6-10; ALJ Decision at 34, FOF 6-11; ALJ Decision at 34, FOF 6-14 and ALJ Decision at 86, Ultimate Finding of Fact 8). Steelhead occurred historically above the Copco 2 and Copco 1 Dams (Hamilton et al. 2005). Steelhead are generally tributary spawners and able to access reaches of tributaries upstream from areas where salmon spawn (Platts and Partridge 1978). Therefore, with fish passage, steelhead would utilize habitat in its entirety in tributaries above the Copco Dams. This means that steelhead would fully have access to the 27.1 miles of habitat including Shovel Creek (ALJ at Decision 12, FOF 2A-5), Beaver and Deer Creeks (ALJ Decision at FOF 34, 6- 14; ALJ Decision at 35, FOF 7-9), as well as Long Prairie, Edge, Frain, Negro, Tom Hayden, and Topsy Creeks (Table 3).

Copco 2 and Copco 1 Downstream Prescription Rationale: Downstream fishways and fishway modifications are prescribed for Copco 2 and Copco 1 Dams. Redband/rainbow trout and other resident fish are currently present in Copco reservoirs. The Services conclude that trout (in particular fry and juveniles) move downstream here as they do in the Klamath River elsewhere (Hemmingsen 1997), a significant portion move through the powerhouses, and turbine entrainment at Copco 2 and Copco 1 Dams causes significant mortality to downstream migrating redband trout (see discussion of turbine-caused mortality later in this paragraph). In addition, with the construction of a functional adult fish ladder at Iron Gate Dam and the Copco Dams, salmon and steelhead would return to hold, spawn, and rear in habitat where they were present historically (Hamilton et al. 2005). The progeny of these fish must negotiate not only the reservoirs but the dams, powerhouses, and spillways during their outmigration. Migration is one of several defining life history characteristics of resident trout and anadromous fish, especially salmonids (ALJ Decision at 27, FOF 3-7; ALJ Decision at 13, FOF 2A-10). To ensure these fish can safely outmigrate, downstream passage around the dams, powerhouses, and spillways is necessary. Fish migrating downstream can suffer injury or death by passing through turbines at hydroelectric plants (Electric Power Research Institute 1987). Turbine caused mortality can have serious consequences for fish populations, especially among anadromous species (Cada 2001). Survival of juvenile salmonids passing dams during their seaward migration is highest through spillways and lowest through turbines (Muir et al. 2001), turbine mortality being caused by pressure changes, cavitation, shear stress, turbulence, strike, and grinding (Cada 2001). The Electric Power Research Institute (Electric Power Research Institute 1987) reported that Francis turbines, which are used at both Copco Dams, had average mortality to downstream moving fish of about 24 percent. In light of the foregoing evidence, the Services conclude that turbine entrainment at each Copco dam presently causes levels of mortality to downstream migrating resident fish comparable to those cited in the studies above and would cause comparable losses of reintroduced anadromous fish populations in the future, absent effective fish screening systems. The Applicant has estimated that approximately 85,848 fish are entrained annually at each mainstem development and has estimated that between 7 to 20 percent of fish passing through the Copco 2 Powerhouse are killed and that between 6 to 18 percent of the fish passing through the Copco 1 Powerhouse are killed ((PacifiCorp 2004a), Exhibit E 4-113). It is estimated that “several tens of thousands of resident fish” are annually entrained at “each of the Projects” facilities (ALJ Decision at 28, FOF 4-2). It is anticipated that annual entrainment of anadromous fish would be on the same order of magnitude, if not greater. Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10 to 30 percent (ALJ Decision at 29, FOF 4-5). Volitional fish passage would be consistent with fish movement through the Klamath River system for purposes such as spawning, rearing, feeding, and seasonal use of habitat. Volitional fish passage is consistent with the goals and objectives for resource management of the Klamath River Basin Fishery Task Force and the Services. The 6 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Tailrace Prescription Rationale: Water discharging from the Copco 2 and Copco 1 powerhouses can represent the major portion of the total river flow of the Klamath. Under the current license, the powerhouses each can discharge up to ~3000 cubic feet per second (cfs) and the Copco 2 bypass reach contains as little as 5–10 cfs. Even with the Applicant’s proposed minimum instream flow, the disparity in flow levels can contribute to false attraction of upstream migrating fish to an area which provides no upstream passage, and delay these fish in their migration. The natural tendency for fish attracted to such an area is to hold and wait for passage conditions to improve, or to attempt to move past the obstacle either by swimming or leaping. Depending on powerhouse operations, draft tube discharge velocities at Project facilities are between 3.4 and 10.4 feet per second (fps) (CH2MHill 2006); these velocities easily fall within the swimming abilities of salmonids (Weaver 1963). The types of injury sustained by some fish entering draft tubes or contacting turbines vary from site to site, as do immediate and delayed mortality rates. Several studies, however, attribute injuries in migrating salmonids to powerhouse structures associated with tailrace structures (Department of Fisheries Canada 1958; International Pacific Salmon Fisheries Commission 1976; Schadt et al. 1985; Williams 1985).

Adult anadromous fish are attracted into oncoming flows (National Marine Fisheries Service 2004). Migration upstream may be delayed when tailrace flows from the powerhouse exceed river bypass reach flows. A migration delay, or combined delays at several facilities, may prevent fish from reaching suitable spawning habitat when they are ready to spawn or conditions are optimal for survival. Migration delays caused by tailrace effects may have a greater impact on fish populations than injury and mortality from turbine impacts (Federal Energy Regulatory Commission 1994). Migration delays may occur to a greater percentage of migrating adults than the percentage of adults impacted by turbine mortality. Migration delays are well documented for anadromous salmonids in the Pacific Northwest (Haynes and Gray 1980; Rondorf et al. 1983; Schadt et al. 1985; Vogel et al. 1990). For migratory adults, false attraction occurs when upstream migrants are attracted to turbine discharge or spillway flows rather than to fishway flows. False attraction also occurs when upstream migrants detect the scent of their natal stream downstream of its natural outlet (Fretwell 1989). This happens when water from a natal stream is diverted through a canal or pipe to a hydroelectric project. In either instance, without proper project design or operation modifications, there may be migratory delays. To prevent injury, delay, or mortality to salmonids, caused by attempts to swim upstream into the tailrace, a barrier is required to guide migrating fish away from this area and encourage them to continue their upstream migration (National Marine Fisheries Service 2004). The 8 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific tailrace barrier prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the tailrace barrier prescriptions. The Applicant subsequently withdrew its request for hearing regarding tailrace barrier prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006- NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the tailrace barrier prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of tailrace barrier s for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the tailrace barriers in order to inform the need for and design of tailrace barriers. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that tailrace barriers are necessary for the upstream passage of fish at Copco 1 and 2 Dams.

Spillway Prescription Rationale: Spill survival estimates for salmonids are numerous and range from 70 percent to 100 percent, depending on species, life stage, amount or proportion of water spilled, spillway configuration, tailwater hydraulics, the methodology of estimating survival, and predator conditions (National Marine Fisheries Service 2000). Fish passing down a spillway may experience physical, chemical, and biological effects. Turbulent mixing of spilled water with receiving waters may result in gas supersaturation and resultant gas bubble disease in fish. Dissolved nitrogen concentrations of more than 130 percent of normal equilibrium levels have been measured in tailwaters (Ebel and Raymond 1976). The threshold value for significant mortality among juvenile Chinook salmon and steelhead trout occurs when nitrogen gas levels are about 115 percent of normal. Along the Columbia River, where many spillways discharge from a given dam and there are many consecutive dams along the stream course, supersaturation increases cumulatively from one dam to the next. Losses of salmon and steelhead trout in the Columbia River due to supersaturation have been severe in years of high spillage (Ebel and Raymond 1976). Fish passing over spillways can be injured by strikes or impacts with solid objects (e.g., baffles, rocks, or walls in the plunge zone), rapid pressure changes, abrasion with the rough side of the spillway, and the shearing effects of turbulent water. After examining the height of Copco 1 Dam, the angle of the spillway, and the stair-stepped design of this spillway, the Services conclude that spill entrainment mortality at the Copco 1 development will likely occur at levels near the high end of the range found in the studies above. While Copco 2 Dam is not as high, mortality may occur here as well. Therefore, spillway modifications and a 6-year timeline are necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific spillway prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the spillway prescriptions. The Applicant subsequently withdrew its request for hearing regarding spillway prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006-NMFS-0001, Order

Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the spillway prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of spillway modifications for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the spillway modifications in order to inform the need for and design of spillway modifications. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that spillway modifications are necessary for the safe, timely and effective passage of fish at Copco 1 and 2 Dams.

Transverse Bedrock Sill Fish Barrier Evaluation/Elimination Rationale: A transverse bedrock sill is located about River Mile 197.3 or 0.5 mile above the Copco 2 Powerhouse (1 mile below Copco 2 Dam). Historical fish distribution upstream from this point (Hamilton et al. 2005) indicates this sill was not a fish barrier prior to the Project, but the sill is a depth barrier to salmonids under the current 5–10 cfs release during normal operation, except during periods of spill, and may continue to be a depth barrier under the flows specified in the new license. This impediment to fish was observed during the summer of 2005 (David K. White, NMFS, pers. comm.). Physical structures, facilities, or devices or sill modification are necessary to eliminate the barrier. The 2 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

4.1 Copco 2 Upstream Fishway

4.1.1 *Copco 2 Upstream Fishway*: The Licensee shall construct, operate, maintain, and evaluate a volitional fishway at Copco 2 Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS criteria (National Marine Fisheries Service 2004) or alternative criteria approved by the Services. The ladder shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The ladder shall have a minimum of two entrances and associated entrance pools and the auxiliary water system (AWS) shall be designed to augment ladder flow from the forebay. The AWS shall be screened in accordance with NMFS juvenile fish screen criteria (National Marine Fisheries Service 1997) or such alternative criteria as may be determined acceptable to NMFS Engineering and the Service. The AWS shall be designed to provide the correct water temperature and water quality to attract fish. The fish ladder and AWS together must be designed to supply attraction flows according to the terms of Modified General Prescriptions 1.1.7 The ladder shall have a maximum drop between pools of 0.5 ft and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1). The ladder shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The upstream fishway must be constructed to current criteria for passage of Pacific lamprey (Table 1). The fishway shall be constructed and operational within 6 years of the issuance of the new license.

4.1.2 *Design Consultation*: The ladder design shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 3 years of the issuance of the new license for review and approval by the Service and NMFS prior to construction.

4.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

4.2 Copco 2 Downstream Fishway

4.2.1 *Intake Fish Screens and Bypass Facility*: The Licensee shall construct, operate, maintain, and evaluate a fish screen and bypass facility for volitional fish passage at Copco 2 Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The screens and bypass facility shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen and bypass facility criteria (National Marine Fisheries Service 1997) or alternative criteria as determined by the Service and NMFS Engineering. The screens and bypass facility shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The bypass facility shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The downstream fishway shall be constructed and operational within 6 years of the issuance of the new license.

4.2.2 *Design Consultation*: The bypass facility design shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 3 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

4.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

4.3 Copco 2 Spillway

4.3.1 *Spillway Modification*: Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 4.3.2 and 4.3.3, the Licensee shall modify, maintain, and evaluate a spillway for the volitional passage at Copco 2 Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The spillway modifications shall be constructed and operational within 6 years of the issuance of the new license.

4.3.2 *Spillway Modification Studies*: The Licensee may, in consultation with the Services, study the need for and design of hydraulically-engineered spillway modifications to improve volitional downstream fish passage at Copco 2 Dam for coho salmon, steelhead trout, Pacific lamprey, and redband trout. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of spillway modifications for review and approval by the Services consistent with the provisions for timing of the spillway design under Modified Specific Prescriptions 4.3.3.

4.3.3 *Spillway Design*: Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 4.3.2, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 4 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

4.3.4 *Spillway Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

4.4 Copco 2 Tailrace Barrier

4.4.1 *Tailrace Barrier Construction*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 4.4.2 and 4.4.3, the Licensee shall construct a tailrace barrier and guidance system at Copco 2 Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The tailrace barrier and guidance system shall be constructed according to approved design plans and within 8 years of the issuance of the new license.

4.4.2 *Tailrace Barrier Studies*: The Licensee may, in consultation with the Services, study the need for and design of a tailrace barrier and guidance system at Copco 2 Dam. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of tailrace barriers for review and approval by the Services consistent with the provisions for timing of the tailrace barrier design under Modified Specific Prescriptions 4.4.3.

4.4.3 *Tailrace Barrier Design*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 4.4.2, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 5 years of the issuance of the new license, for review and approval by the Service and NMFS Engineering prior to construction.

4.4.4 *Tailrace Barrier Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

4.5 Copco 2 Bypass Channel Barrier/Impediment Elimination

4.5.1 *Barrier Modification*: The Licensee shall construct physical structures, facilities, or devices or modify the sill (as provided in 4.5.2 below), unless the Licensee demonstrates through an evaluation (conducted in consultation with the Services and CDFG and in a manner approved by the Services) using accepted fish barrier evaluation methodology (Powers and Orsborn 1985) that the transverse bedrock sill approximately 0.5 miles above the Copco 2 Powerhouse in the Copco 2 bypassed reach is not a barrier to fish passage under normal operating flows specified for the Copco 2 bypassed reach in the new license. The evaluation shall be completed within six months of the issuance of the new license and its conclusions must be approved by the Services.

4.5.2 *Design and Construction*: The Licensee shall develop design and construction plans for the physical structures, facilities, devices or barrier modification according to the terms of the Modified General Prescriptions article 1.1.1 above within 1 year of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction. The physical structures, facilities, devices or barrier modification shall be constructed within 2 years of license issuance, in accordance with specified guidelines and criteria for fish passage (National Marine Fisheries Service 2004), including, if the sill is not bypassed, providing at least 1.0 foot of swimming depth across the sill and with adequate attraction, velocity, capacity, and vertical jump characteristics.

4.5.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

5. Copco 1 Dam

5.1 Copco 1 Dam Upstream Fishway

5.1.1 *Copco 1 Upstream Fishway*: The Licensee shall construct, operate, maintain, and evaluate a volitional upstream fishway at Copco 1 Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS criteria (National Marine Fisheries Service 2004) or alternative criteria approved by the Services. The ladder shall provide for the uninterrupted passage of fish over the full river flows for which the Project maintains operational control. The ladder shall have a minimum of two entrances and associated entrance pools and the auxiliary water system (AWS) shall be designed to augment ladder flow from the forebay. The AWS shall be screened in accordance with NMFS juvenile fish screen criteria (National Marine Fisheries Service 1997) or such alternative criteria as may be determined acceptable to NMFS Engineering and the Service. The AWS shall be designed to provide the correct water temperature and water quality as to attract fish. The fish ladder and AWS together must be designed to supply attraction flows according to the terms of Modified General Prescriptions 1.1.7 The ladder shall have a maximum drop between pools of 0.5 ft and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1). The ladder shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The Licensee shall construct the upstream fishway according to current criteria for passage of Pacific lamprey (Table 1). The fishway shall be constructed and operational within 6 years of the issuance of the new license.

5.1.2 *Design Consultation*: The ladder design shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 3 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

5.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

5.2 Copco 1 Downstream Fishway

5.2.1 *Intake Fish Screens and Bypass Facility*: The Licensee shall construct, operate, maintain, and evaluate a fish screen and bypass facility for volitional fish passage at Copco 1 Dam to below Copco 1 Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The screens and bypass facility shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen and bypass facility criteria (National Marine Fisheries Service 1997) or alternative criteria as determined by the Service and NMFS Engineering. The screens and bypass facility shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The bypass facility shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The downstream fishway shall be constructed and operational within 6 years of the issuance of the new license.

5.2.2 *Design Consultation*: The bypass facility design shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 3 years of the issuance of the new license for review and approval by the Service and NMFS prior to construction.

5.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

5.3 Copco 1 Spillway

5.3.1 *Spillway Modification*: Unless the Services determine, based on site-specific studies, that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 5.3.2 and 5.3.3, the Licensee shall modify, maintain, and evaluate a spillway for volitional passage at Copco 1 Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The spillway modifications shall be constructed and operational within 6 years of the issuance of the new license.

5.3.2 *Spillway Modification Studies*: The Licensee may, in consultation with the Services, study the need for and design of hydraulically-engineered spillway modifications to improve volitional downstream fish passage at Copco 1 Dam for Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of spillway modifications for review and approval by the Services consistent with the provisions for timing of the spillway design under Modified Specific Prescriptions 5.3.3.

5.3.3 *Spillway Design*: Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 5.3.2, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 4 years of the issuance of the new license for review and approval by the Service and NMFS prior to construction.

5.3.4 *Spillway Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

5.4 Copco 1 Tailrace Barrier

5.4.1 *Tailrace Barrier Construction*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Specific Modified Prescriptions 5.4.2 and 5.4.3, the Licensee shall construct a tailrace barrier and guidance system at Copco 1 Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The tailrace barrier and guidance system shall be constructed according to approved design plans and within 8 years of the issuance of the new license.

5.4.2 *Tailrace Barrier Studies*: The Licensee may, in consultation with the Services, study the need for and design of a tailrace barrier and guidance system at Copco 1 Dam. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of tailrace barriers for review and approval by the Services consistent with the provisions for timing of the tailrace barrier design under Modified Specific Prescriptions 5.4.3.

5.4.3 *Tailrace Barrier Design*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 5.4.2, the Licensee shall, within 5 years of the issuance of the new license, develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 for review and approval by the Service and NMFS Engineering prior to construction.

5.4.4 *Tailrace Barrier Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

6. J.C. Boyle Dam

Upstream Prescription Rationale: Historically coho salmon, steelhead, and spring-run and fallrun Chinook salmon (Hamilton et al. 2005; ALJ Decision at 12, FOF 2A-3 through 2A-6) and resident trout (Hanel and Gerlach 1964) migrated above the current site of J.C. Boyle Dam to reach holding, spawning, incubation, and rearing habitat. The upstream fishway at J.C. Boyle Dam is obsolete and does not meet current design criteria. It is a partial barrier to trout passage and, thus, to critical holding, spawning, incubation, and rearing habitat in tributaries (Spencer, Hunters Park, and Miners Creeks) and the Boyle Reservoir to Keno Dam reach (Table 3). Suitable habitat for anadromous fish occurs in Spencer Creek, a perennial stream (ALJ Decision at 34, FOF 6-11; ALJ Decision at 35, FOF 7-9), intermittent streams (ALJ Decision at 34, FOF 6-14; ALJ Decision at 35, FOF 7-9), and the main stem (ALJ Decision at 33, FOF 6-10; ALJ Decision at 35, FOF 7-9).

The goal of the Services and the Klamath River Basin Fisheries Task Force is to successfully restore corresponding life history phases of anadromous salmonids to their historical range and this suitable habitat. The Service goal is to successfully restore resident fish to their historical range and suitable habitat as well. The objective in reaching these goals is the restoration of safe, timely, and effective fish movement. Providing fishways that meet current criteria at J.C. Boyle Dam is consistent with the goals and objectives for resource management of the Services and the Klamath River Basin Fisheries Task Force. The 4-year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Benefits: Specific benefits of fishways at J.C. Boyle Dam include:

- Resident Trout: Fish passage at J.C. Boyle Dam alone would restore the unimpaired connectivity of resident redband trout populations in the mainstem Klamath River with those in Spencer Creek. This tributary, in particular, provides important habitat elements, such as spawning and temperature related refugial areas for redband trout. A number of reports document the importance of Spencer Creek habitat to redband trout (Buchanan et al. 1990; Buchanan et al. 1991; Hemmingsen 1997; Hemmingsen et al. 1992; USDI Bureau of Land Management et al. 1995). The Spencer Creek population of Klamath River redband trout is migratory and has connectivity to the population in the mainstem Klamath River and nearby tributary watersheds. This Basin connectivity coupled with homing behavior (and straying of individuals) allows Spencer Creek redband/rainbow trout to be a source of adaptive variability in Klamath Basin trout populations (USDI Bureau of Land Management et al 1995). This connectivity has been greatly impaired by inadequate passage at J.C. Boyle Dam. The number of redband trout using the J.C. Boyle fish ladder have declined 90 percent or more since shortly after the dam was constructed (Hanel and Gerlach 1964; Hemmingsen et al. 1992; Oregon Department of Fish and Wildlife 2006). An upstream ladder, built to current criteria and with the entrance located to avoid false attraction flows, would provide for the safe, timely and effective passage around J.C. Boyle Dam for redband trout migrating to Spencer Creek and upstream. With fish passage, habitat in Spencer Creek and habitat between J.C. Boyle Dam and Keno Dam would be fully utilized. Seasonal migration of redband trout and access to refugial areas would be restored.

- Coho: Coho salmon are present in the Klamath River below Iron Gate Dam and were present historically below and above the J.C. Boyle Dam to at least Spencer Creek (Hamilton et al. 2005). Access to habitat within the Project would benefit coho salmon by: a) extending the range and distribution of the species thereby increasing the reproductive potential; b) increasing genetic diversity in the coho stocks; c) reducing the species vulnerability to the impacts of degradation; and d) increasing the abundance (ALJ Decision at 86, Ultimate Finding of Fact 9; ALJ Decision at 36, FOF 7-16). With passage at J.C. Boyle Dam, coho salmon would regain access to suitable habitat (Table 3; ALJ Decision at 35, FOF 7-9). With fish passage, access to this habitat would no longer be unutilized. Seasonal migration of coho and access to refugial areas would be restored.

- Spring-run Chinook: With fish passage at J.C. Boyle Dam, spring-run Chinook salmon would regain access to seasonal cool water refugial areas necessary for this run of fish (McCullough 1999) between J.C. Boyle Dam and the next dam upstream (Keno Dam). Spring-run Chinook would also have access to the main channel as an upstream migration corridor necessary to reach historical spawning areas in the Upper Klamath Basin (California Department of Fish and Game 1990).

- Fall Chinook: With fish passage, fall-run Chinook salmon would regain access to 14.3 miles of habitat, including tributaries and the mainstem Klamath River (Table 3) between J.C. Boyle Dam and the next dam upstream (Keno Dam). With fish passage seasonal migration of fall-run Chinook and access to refugial areas would be restored.

- Pacific Lamprey: With fish passage, Pacific lamprey would gain access to habitat, including tributaries and the mainstem Klamath River (Table 3) between J.C. Boyle Dam and the next dam upstream (Keno Dam). This access to habitat would benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the genetic diversity of the species; and d) increasing the abundance of the Pacific lamprey population (ALJ Decision at 38, FOF 8-9).

- Steelhead: With fish passage, steelhead would regain access to 17.1 miles of habitat between J.C. Boyle Dam and the next dam upstream (Keno Dam). Steelhead are generally tributary spawners and able to access reaches of tributaries upstream from areas where salmon spawn (Platts and Partridge 1978). Therefore, with fish passage, steelhead would utilize habitat in its entirety in tributaries above J.C. Boyle Dam. This means that steelhead would fully have access to 17.1 miles of habitat including Spencer Creek (ALJ Decision at 12, FOF 2A-5), Hunters Park and Miners Creeks, as well as the mainstem Klamath River (ALJ Decision at 35, FOF 7-9) below Keno Dam (Table 3; ALJ Decision at 33, FOF 6-10; ALJ Decision at 34, FOF 6-11; ALJ Decision at FOF 34, 6-14 and ALJ Decision at 86, Ultimate Finding of Fact 8). Seasonal migration of steelhead and access to refugial areas would be restored.

Downstream Prescription Rationale: Redband/rainbow trout, federally listed suckers, and other resident fish are currently present in J.C. Boyle Reservoir ((Desjardins and Markle 2000; PacifiCorp 2004b) Fish Resources FTR). The Services conclude that trout (in particular fry and juveniles) move downstream as they do in the Klamath River elsewhere (Hemmingsen 1997) and that the vast majority of these move through the J.C. Boyle Powerhouse because the screens are ineffective and the facility seldom spills. Dam operators at the J.C. Boyle development generally do not spill until Klamath River discharge exceeds 3,000 cfs. Over the past 25 years the Klamath River exceeded this threshold a median of 4.5 days per year and in 12 years it did not exceed 3,000 cfs (Oregon Department of Fish and Wildlife 2006). The Services conclude that turbine entrainment at J.C. Boyle Dam causes significant mortality to downstream migrating redband trout (see discussion of turbine-caused mortality later in this paragraph; ALJ Decision at 86, Ultimate Findings of Fact 6 and 7). With the construction of a functional adult fish ladder at J.C. Boyle Dam, salmon, and steelhead would return to hold, spawn, and rear in habitat where they were present historically (Hamilton et al. 2005). However, the progeny of these fish would also move downstream and must negotiate not only the reservoir but the dam, powerhouse, and spillway during their outmigration. Migration is one of several defining life history characteristics of resident trout and anadromous fish, especially salmonids (ALJ Decision at 27, FOF 3-7; ALJ Decision at 13, FOF 2A-10). Turbine caused mortality at dams can have serious consequences for fish populations, especially among anadromous species (Cada 2001). Survival of juvenile salmonids passing dams during their seaward migration is highest through spillways and lowest through turbines (Muir et al. 2001), turbine mortality being caused by pressure changes, cavitation, shear stress, turbulence, strike, and grinding (Cada 2001). The Electric Power Research Institute (EPRI) (Electric Power Research Institute 1987) reported that the Francis turbines which are used at the J.C. Boyle development have an average mortality of about 24 percent for all subject species. EPRI's studies, and those of Milo Bell (Bell 1986; Bell et al. 1967) measured entrainment for some of the same species and under similar conditions as exist at J.C. Boyle Dam, and thus support the conclusion that entrainment mortality is presently occurring at significant levels for resident fish. The J.C. Boyle development, at 440 feet of head, may have even greater mortality due to turbine entrainment, as pressure gradients will be even greater. For projects with Francis turbines, the EPRI study found a high correlation ($r = 0.77$) between head and fish mortality. Four hydroelectric developments with Francis turbines that had greater than 335 feet of head had mortality ranging from 33 to 48 percent (Electric Power Research Institute 1987); ALJ Decision at 29, FOF 4-10). The facilities in these studies have comparable or less hydraulic head than the J.C. Boyle development and comparable turbine types. Using the above evidence, the Services conclude that entrainment mortality at J.C. Boyle Powerhouse likely falls in this range (ALJ Decision at 30, Decision 4-11) rather than the 12 to 36 percent range estimated by the Applicant (PacifiCorp 2004a), Exhibit E 4-113). It is estimated that "several tens of thousands of resident fish" are annually entrained at "each of the Projects" facilities (ALJ Decision at 28, Decision 4-2). It is anticipated that annual entrainment of anadromous fish would be on the same order of magnitude, if not greater. Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10 to 30 percent (ALJ Decision at 29, Decision 4-5). When anadromous fish are restored above J.C. Boyle Dam, outmigrating salmonid smolts, including federally listed coho, would be entrained and a significant portion killed during turbine passage absent downstream fish screens and bypass systems. Volitional fish passage would be consistent with fish movement through Klamath River system for purposes such as spawning, rearing, feeding, and seasonal use of habitat. It is also consistent with the goals and resource management objectives of the Klamath River Basin Fishery Task Force and the Services.

PacifiCorp recognizes that entrainment at J.C. Boyle dam is a "problem that needs to be addressed" (ALJ Decision at 30, FOF 4-12). The development of detailed design and construction plans for review and approval by the Service and NMFS Engineering is critical to ensure that effective passage measures are incorporated into the design. The 4-year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Sidecast Rock Barrier Elimination Prescription Rationale: Sidecast rock extends from the J.C. Boyle canal access road into and across the J.C. Boyle bypass channel, blocking or inhibiting fish passage. Presently, all flows in the bypass reach filter through the sidecast rock and there is no unimpeded route for anadromous and resident fish passage at the typical bypass flows observed. The rock has been deposited in this channel recently and is sidecast from Project construction and operation of the J.C. Boyle canal and access road. This impediment to fish was observed during the summer of 2005 (David K. White, NMFS, pers. comm.). Historically, higher flows in the bypassed channel might have been able to disperse this material and restore fish movement. Physical structures, facilities, devices or barrier removal are necessary to achieve the safe, timely, and effective passage through the channel past this obstruction and would be consistent with the goals and objectives for resource management of the Services and the Klamath River Basin Fishery Task Force. The 2 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Tailrace Prescription Rationale: Water discharging from the J.C. Boyle Powerhouse represents a significant portion of the total river flow of the Klamath River. Under the current license the powerhouse can discharge up to 3,000 cubic feet per second (cfs) and the bypass reach contains as little as 320 cfs. Even with the instream flow in the bypassed channel proposed by the Applicant, this disparity in flows contributes to false attraction for upstream migrating fish to an area which provides no upstream passage. The natural tendency for fish attracted to such an area is to hold and wait for passage conditions to improve or to attempt to move past the obstacle either by swimming or leaping. Depending on powerhouse operations, draft tube discharge velocities at Project facilities are between 3.4 and 10.4 feet per second (fps) (CH2MHill 2006); these velocities easily fall within the swimming abilities of salmonids (Weaver 1963). The types of injury sustained by some fish entering draft tubes or contacting turbines vary from site to site, as do immediate and delayed mortality rates. Several studies, however, attribute injuries in migrating salmonids to powerhouse structures associated with tailrace structures (Department of

Fisheries Canada 1958; International Pacific Salmon Fisheries Commission 1976; Schadt et al. 1985; Williams 1985).

Adult anadromous fish are attracted into oncoming flows (National Marine Fisheries Services 2004) as are resident fish. Migration upstream may be delayed when tailrace flows from the powerhouse exceed river bypass reach flows. A migration delay, or combined delays at several facilities, may prevent fish from reaching suitable spawning habitat when they are ready to spawn or conditions are optimal for survival. Migration delays caused by tailrace effects may have a greater impact on fish populations than injury and mortality from turbine impacts (Federal Energy Regulatory Commission 1994). Migration delays may occur to a greater percentage of migrating fish than the percentage of fish impacted by turbine mortality. Migration delays are well documented for anadromous salmonids in the Pacific Northwest (Haynes and Gray 1980; Rondorf et al. 1983; Schadt et al. 1985; Vogel et al 1990). For migratory fish, false attraction occurs when upstream migrants are attracted to turbine discharge or spillway flows rather than to fishway flows. False attraction also occurs when upstream migrants detect the scent of their natal stream downstream of its natural outlet (Fretwell 1989). This happens when water from a natal stream is diverted through a canal or pipe to a hydroelectric project. In either instance, without proper project design or operation modifications, there may be migratory delays.

In order to prevent injury, delay, or mortality to salmonids, caused by attempts to swim upstream into the tailrace, a barrier is required to guide migrating fish away from this area and encourage them to continue their upstream migration. The 4 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific tailrace barrier prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the tailrace barrier prescriptions. The Applicant subsequently withdrew its request for hearing regarding tailrace barrier prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006- NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the tailrace barrier prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of tailrace barriers for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the tailrace barriers in order to inform the need for and design of tailrace barriers. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that tailrace barriers are necessary for the safe, timely and effective upstream passage of fish at J.C. Boyle Dam.

Spillway Prescription Rationale: Spill survival estimates for juvenile salmonids are numerous and range from 76 percent to 100 percent, depending on species, life stage, amount or proportion of water spilled, spillway configuration, tailwater hydraulics, the methodology of estimating survival, and predator conditions (National Marine Fisheries Service 2000). Fish passing down a spillway may experience physical, chemical, and biological effects. Turbulent mixing of spilled water with receiving waters may result in gas supersaturation and resultant gas bubble disease in fish. Dissolved nitrogen concentrations of more than 130 percent of normal equilibrium levels have been measured in tailwaters (Ebel and Raymond 1976). The threshold value for significant mortality among juvenile Chinook salmon and steelhead trout occurs when nitrogen gas levels are about 115 percent of normal. Along the Columbia River, where many spillways discharge from a given dam and there are many consecutive dams along the stream course, supersaturation increases cumulatively from one dam to the next. Losses of salmon and steelhead trout in the Columbia River due to supersaturation have been severe in years of high spillage (Ebel and Raymond 1976). Fish passing over spillways can be injured by strikes or impacts with solid objects (e.g. baffles, rocks, or walls in the plunge zone), rapid pressure changes, abrasion with the rough side of the spillway, and the shearing effects of turbulent water.

The configuration of the J.C. Boyle Dam spillway includes numerous rocks and many such solid objects and it is reasonable to conclude that significant mortality will occur while passing fish through the spillway. Therefore, the following spillway modifications and 4 year timeline are necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific spillway prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the spillway prescriptions. The Applicant subsequently withdrew its request for hearing regarding spillway prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006-NMFS-0001, Order Granting the Applicant’s Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the spillway prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of spillway modifications for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the spillway modifications in order to inform the need for and design of spillway modifications. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that spillway modifications are necessary for the safe, timely, and effective passage of fish at J.C. Boyle Dam.

6.1 J.C. Boyle Bypass Channel

6.1.1 *Barrier Elimination*: The Licensee shall construct physical structures, facilities, or devices to provide passage around or remove the sidecast rock barrier approximately 2.5 mile above the J.C. Boyle Powerhouse in the J.C. Boyle Bypass reach within 2 years of the issuance of the new license to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout.

6.1.2 *Design and Construction*: The Licensee shall develop design, construction, and maintenance plans according to the terms of the Modified General Prescriptions 1.1.1 above within 1 year of the issuance of the new license for review and approval by the Service and NMFS prior to construction.

6.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

6.2 J.C. Boyle Upstream Fishway

6.2.1 *J.C. Boyle Upstream Fishway*: The Licensee shall construct, operate, maintain, and evaluate a volitional fishway at J.C. Boyle Dam to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The fishway shall be operated year-round and shall consist of a fish ladder designed in accordance with NMFS' criteria (National Marine Fisheries Service 2004) or alternative criteria approved by the Services. The ladder shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The ladder shall have a minimum of two entrances and associated entrance pools and the auxiliary water system (AWS) shall be designed to augment ladder flow from the forebay. The ladder entrance shall be located downstream of the fish screen bypass outfall and existing velocity barrier below the existing ladder. The AWS shall be screened in accordance with NMFS juvenile fish screen criteria (National Marine Fisheries Service 1997), or such alternative criteria as may be determined acceptable by NMFS Engineering and the Service. The AWS shall be designed to provide the correct water temperature and water quality as to attract fish. The fish ladder and AWS together must be designed to supply attraction flows according to the terms of Modified General Prescriptions 1.1.7. The ladder shall have a maximum drop between pools of 0.5 ft and the maximum slope of the fish ladder shall not exceed 10 percent (Table 1). The ladder shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The upstream fishway shall be constructed to current criteria for passage of Pacific lamprey. The fishway shall be constructed and operational within 4 years of the issuance of the new license.

6.2.2 *Design Consultation*: The ladder design shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 2 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

6.2.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

6.3 J.C. Boyle Downstream Fishway

6.3.1 *Intake Fish Screens and Bypass Facility*: The Licensee shall construct, operate, maintain, and evaluate a new fish screen and a bypass facility at J.C. Boyle Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The screen and bypass shall be operated year-round and shall be designed in accordance with NMFS juvenile fish screen and bypass facility criteria (National Marine Fisheries Service 1997) or alternative criteria acceptable to the Service and NMFS Engineering. The screen and bypass facility shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The screen shall divert all fish to a bypass facility. The bypass facility shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall complete construction and begin operation within 4 years of the issuance of the new license.

6.3.2 *Design Consultation*: The bypass facility design shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology). The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 2 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

6.3.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

6.4 J.C. Boyle Spillway

6.4.1 *Spillway Modification*: Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 6.4.2 and 6.4.3, the Licensee shall modify, maintain, and evaluate a spillway for the volitional passage at J.C. Boyle Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The spillway modifications shall be constructed and operational within 4 years of the issuance of the new license.

6.4.2 *Spillway Modification Studies*: The Licensee may, in consultation with the Services, study the need for and design of hydraulically-engineered spillway modifications to improve volitional downstream fish passage at

J.C. Boyle Dam for Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of spillway modifications for review and approval by the Services consistent with the provisions for timing of the spillway design under Modified Specific Prescriptions 6.4.3.

6.4.3 *Spillway Design*: Unless the Services determine based on site-specific studies that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 6.4.2, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 3 years of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction.

6.4.4 *Spillway Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

6.5 J.C. Boyle Tailrace Barrier

6.5.1 *Tailrace Barrier Construction*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 6.5.2 and 6.5.3, the Licensee shall construct a tailrace barrier and guidance system at J.C. Boyle Dam to provide for the safe, timely, and effective passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. The tailrace barrier and guidance system shall be constructed according to approved design plans and within 4 years of the issuance of the new license

6.5.2 *Tailrace Barrier Studies*: The Licensee may, in consultation with the Services, study the need for and design of a tailrace barrier and guidance system at the J.C. Boyle Powerhouse. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of tailrace barriers for review and approval by the Services consistent with the provisions for timing of the tailrace barrier design under Specific Modified Prescriptions 6.5.3.

6.5.3 *Tailrace Barrier Design*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 6.5.2, the Licensee shall, within 3 years of the issuance of the new license, develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 for review and approval by the Service and NMFS Engineering prior to construction.

6.5.4 *Tailrace Barrier Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

7. Keno Dam

Upstream Prescription Rationale: Historically steelhead, spring-run and fall-run Chinook salmon (Hamilton et al. 2005; ALJ Decision at 12, FOF 2A-3 through 2A-5), and resident fish migrated through the current site of Keno Dam to reach holding, spawning, incubation, and rearing habitat. Keno Dam is a partial barrier to this passage and, thus, to holding, spawning, incubation, and rearing habitat in the Link River reach. The goal of the Services and the Klamath River Basin Fisheries Task Force is to successfully restore corresponding life history phases of anadromous salmonids to their historical range and suitable habitat. The goal of the Service is to successfully restore resident fish to their historical range and suitable habitat as well. The objective in reaching these goals is restoration of safe, timely, and effective fish movement. Providing fish passage that meets current standards at Keno Dam is consistent with goals and objectives for resource management of the Services and the Klamath River Basin Fisheries Task Force. The provision of effective fish passage facilities will meet these goals and provide mitigation for the impacts of the dam.

Keno Impoundment in its current state would be primarily a migration corridor for anadromous salmonids because the depth and velocity of the impoundment provide little suitable habitat. Link River is the only free flowing reach of the Klamath River between Keno Dam and Link River Dam. Link River provides habitat for Klamath large scale suckers (Catastomus snyderi) during all months of the year, and for Lost River and shortnose suckers in summer when water quality is poor in downstream Lake Ewauna (Rich Piaskowski, Reclamation, pers. comm.) For salmonids, Link River provides habitat most of the year other than summer months. During most years, the Lake Ewauna reach of the Klamath River (Link River Dam to Keno Dam) has dissolved oxygen concentrations greater than 6 mg/L and temperatures less than 20°C from mid-November through mid-June (Jason Cameron, Reclamation, pers. comm.). These conditions are within the criteria for migrating adult anadromous salmonids for these months (U.S. Environmental Protection Agency 2003). For steelhead trout, the Services expect that adult returns would occur primarily from October through March. Major runs of spring-run Chinook and fall-run Chinook salmon would occur from March to June and September to December, respectively. Because of their run timing, passage of fall-run Chinook may be affected by conditions in Lake Ewauna. Interim, seasonal, upstream trap and haul for primarily fall-run adult Chinook salmon around Keno Impoundment and Lake Ewauna would be necessary during the period June 15 to November 15 when DO and temperature are out of criteria for this life stage of this species (U.S. Environmental Protection Agency 2003) and water quality conditions may not be suitable for migration. The Services expect trap and haul to be an effective interim, seasonal fish passage method for adult fall-run Chinook salmon during the period June 15 to November 15 because only this species would be transported and only for a short distance. Other species need volitional fishways to access habitat in Keno Impoundment and Link River year round. Conditions in this reach are expected to improve over time to a point when volitional passage will be effective year-round for all target species. Water quality is expected to improve over the term of a new Project license through the implementation of the Total Maximum Daily Load (TMDL) process, imposition of state water quality certification conditions, and provisions of a new license, including terms and conditions added by the Commission and based on the recommendations of the Agencies pursuant to FPA section 10(j). Upper Klamath Lake above Link River Dam currently provides habitat for salmonids. Water quality problems in the lake during the summer months are relatively short lived and springs in the lake provide thermal refugial areas for redband trout and other species. Redband trout are also well known for migrating upstream into the Wood and Williamson Rivers when Upper Klamath Lake water quality deteriorates. Once fish pass Keno Dam, Keno Impoundment, and Lake Ewauna, the current upstream fishway at Link River Dam would pass anadromous fish species (including Pacific lamprey) on their way to currently available, good quality upstream habitat (Huntington 2006; Oregon Department of Fish and Wildlife 1997). The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

Keno Dam may impede native suckers occupying habitat below the dam from reaching elements of their historical habitat including Lake Ewauna, Link River, and Upper Klamath Lake, the core recovery area for this species (USDI Fish and Wildlife Service 1993). The existing fishway at Keno Dam does not meet Service and ODFW criteria for sucker passage (Table 1) because the slope is too steep (USDI Fish and Wildlife Service 2005). However, the potential contribution of the J.C. Boyle Reservoir population occupying habitat below Keno Dam for conservation of the species may be limited. Monitoring of fish passage at Keno Dam has demonstrated small numbers of fish moving upstream through the existing ladder at Keno Dam (PacifiCorp 1997). Until additional information becomes available regarding the populations of federally listed suckers in J.C. Boyle Reservoir and the need for passage of federally listed suckers upstream, the Service reserves its authority to prescribe an upstream fishway to sucker criteria at Keno Dam.

Benefits of fishways at Keno Dam include:

- Resident Trout: Significant recreational fisheries for redband trout currently exist in the Project area, as well as in and upstream of Upper Klamath Lake. Upstream fish passage at Keno Dam would result in restoring the connectivity of resident redband populations in the mainstem Klamath River with those in Keno Impoundment/Lake Ewauna, Link River, and Upper Klamath Lake. In 2005, The Bureau of Reclamation completed a new fishway at Link River Dam designed to pass endangered suckers, trout, lamprey, and other native species. Adequate upstream fish passage at Link River Dam has resulted in restoring the connectivity of resident redband populations in the Link River reach with those in Upper Klamath Lake and its tributaries. These tributaries, including the Wood, Williamson, and Sprague Rivers in particular, provide important habitat elements, such as spawning and temperature related refugial areas for redband trout (Oregon Department of Fish and Wildlife 1997). With fish passage, habitat between Keno and Link River Dam would be fully utilized. Seasonal migration of trout and access to refugial areas would be improved.

- Spring-run Chinook salmon, fall-run Chinook, and steelhead: All these species occurred historically above the current site of Keno Dam and Upper Klamath Lake (Hamilton et al. 2005; ALJ Decision at 12, FOF 2A-3 through 2A-5). With upstream fishways at downstream dams and the new ladder at Link River Dam, adequate anadromous fish passage facilities at Keno Dam would mean these runs would regain access to 49 significant tributaries in the Upper Klamath Basin, comprising 360 miles of currently productive anadromous fish habitat (if anadromous fish had access to this habitat) and an additional 60 miles of recoverable habitat (Huntington 2006). Large populations of spring-run Chinook were found in several of the tributaries to Upper Klamath Lake, including both the Williamson and Sprague Rivers (California Department of Fish and Game 1990). Historical run sizes in both the Williamson River and the Sprague River were estimated to be at least 5,000 spring-run Chinook salmon (California Department of Fish and Game 1990). Substantial numbers of what were apparently fall-run Chinook were still being harvested in the Sprague River up until about 1910 (Lane and Lane Associates 1981). Steelhead are generally tributary spawners and able to access reaches upstream from areas where salmon spawn (Platts and Partridge 1978). Therefore, with fish passage, steelhead would have access to tributaries above Keno Dam. Seasonal migration of anadromous salmonids and access to refugial areas would be restored.

- Pacific lamprey: At Keno Dam the existing fishway does not meet current criteria to accomplish lamprey passage because corners and ladder steps are not rounded (USDI Fish and Wildlife 2005). Lampreys occur long distances inland in the Columbia and Yakima river systems (Wydoski and Whitney 2003) and would likely do so in the Klamath River system as well, as habitat conditions are similar. Access to habitat above Keno Dam would likely benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the genetic diversity of the species; and d) increasing the abundance of the Pacific lamprey population (ALJ Decision at 38, FOF 8-9). Resident lamprey would benefit from a fishway that meets current criteria to accomplish lamprey passage.

Spillway Prescription Rationale: Spill survival estimates for salmonids are numerous and range from 76 percent to 100 percent depending on species, life stage, amount or proportion of water spilled, spillway configuration, tailwater hydraulics, the methodology of estimating survival, and predator conditions (National Marine Fisheries Service 2000). Fish passing down a spillway may experience physical, chemical, and biological effects. Fish passing over spillways can be injured by strikes or impacts with solid objects (e.g., baffles, rocks, or walls in the plunge zone), rapid pressure changes, abrasion with the rough side of the spillway, and the shearing effects of turbulent water. Water exits Keno spillways via undershot gates with small openings and plunges into a wide, shallow bedrock sill that is an area known for predatory fish (Oregon Department of Fish and Wildlife 1997). It is likely that fish will be injured as water is passed through the gates under pressure and that predation will occur in the receiving waters. Therefore, the spillway modifications and 3 year timeline are necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific spillway prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the spillway prescriptions. The Applicant subsequently withdrew its request for hearing regarding spillway prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006-NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the spillway prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of spillway modifications for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the spillway modifications in order to inform the need for and design of spillway modifications. However, unless and until such site-specific studies are done, the Services must rely on the available information in concluding that spillway modifications are necessary for the safe, timely and effective passage of fish at Keno Dam.

7.1 Upstream Fishway at Keno Dam

7.1.1 *Keno Upstream Fishway*: To provide for the safe, timely, and effective upstream passage of Chinook salmon, steelhead trout, Pacific lamprey, and redband trout, the Licensee shall modify, operate, and maintain the existing volitional fishway. The Licensee shall also construct, operate, and maintain a holding and sorting facility to accommodate upstream interim, seasonal trap and haul for anadromous salmonids at Keno Dam. In addition, the modification shall include features to trap, hold, and sort anadromous salmonids by age and species, as well as accomplish the transfer of Chinook salmon upstream above Link River Dam between June 15 and November 15 for the purposes of restoration and the safe, effective, and timely passage of fish. If agreed to by the Services, volitional passage shall be employed during this time in periods when dissolved oxygen concentrations are greater than 6 mg/L and temperatures lower than 20°C, as measured at Miller Island using a method that is acceptable to the Services. The upstream fishway shall be operated year-round regardless of trap and haul operations to allow for the passage of steelhead, Chinook salmon, redband trout, lampreys, suckers, and other species. The ladder shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The auxiliary water system (AWS) shall be designed to augment ladder flow from the forebay. The AWS shall be screened in accordance with NMFS juvenile fish screen criteria (National Marine Fisheries Service 1997) or alternative criteria approved by the Services. The AWS shall be designed to provide the correct water temperature and water quality as to attract fish. The fish ladder and AWS together must be designed to supply attraction flows according to the terms of Modified General Prescriptions 1.1.7 The ladder shall include features to detect and record data for PIT-Tagged upstream migrating anadromous fish (or fish identified using similar technology). The upstream fishway shall be modified to current criteria (Table 1) for passage of Pacific lamprey. The fishway shall be modified and operational within 3 years of the issuance of the new license.

7.1.2 *Design Consultation*: The Licensee shall develop design and modification plans according to the terms of the Modified General Prescriptions 1.1.1 above within 1 year of the issuance of the new license for review and approval by the Service and NMFS Engineering prior to construction. The design shall include features to hold and sort anadromous salmonids by age and species, as well as accomplish the transfer of Chinook salmon upstream between June 15 and November 15 for the purposes of restoration and the safe, effective, and timely passage of fish. Facilities shall be designed so that fish to be trapped and hauled above Keno are held a maximum of 8 hours before transport. The ladder design shall include features to detect and record data for PIT-tagged upstream migrating anadromous fish (or fish identified using similar technology). The upstream fishway must be modified to current criteria for passage of Pacific lamprey.

7.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

7.2 Keno Spillway

7.2.1 *Spillway Modification*: Unless the Services determine, based on site-specific studies, that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 7.2.2 and 7.2.3, the Licensee shall modify, maintain, and evaluate the radial gate(s) to provide a spillway at Keno Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, suckers, lamprey, steelhead trout, and redband trout. The spillway modifications shall be constructed and operational within 3 years of the issuance of the new license.

7.2.2 *Spillway Modification Studies*: The Licensee may, in consultation with the Services, study the need for and design of hydraulically-engineered modifications to the radial gate(s) to provide a spillway (s) at Keno Dam to provide for the safe, timely, and effective downstream passage of Chinook and coho salmon, suckers, lamprey, steelhead trout, and redband trout. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of spillway modifications for review and approval by the Services consistent with the provisions for timing of the spillway design under Modified Specific Prescriptions 7.2.3.

7.2.3 *Spillway Design*: Unless the Services determine, based on site-specific studies, that spillway modifications are unnecessary in accordance with Modified Specific Prescriptions 7.2.2, the Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 2 years of the issuance of the new license for review and approval by the Service and NMFS engineering prior to construction.

7.2.4 *Spillway Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in the Modified General Prescriptions, above.

8. Eastside and Westside Developments

Eastside and Westside Downstream Prescription Rationale: The Applicant’s Eastside and Westside developments divert water at Link River Dam to downstream powerhouses. Migration is one of several defining life history characteristics of resident trout and anadromous fish, especially salmonids (ALJ Decision at 27, FOF 3-7; ALJ Decision at 13, FOF 2A-10). Significant numbers of redband trout and other resident fish are presently moving downstream from Upper Klamath Lake and being entrained by the Applicant’s Eastside and Westside developments, including tens of thousands of larvae and juveniles of federally listed suckers annually (Gutermuth et al. 2000). With the adult fish ladder in place at Reclamation's Link River Dam and construction of functional adult fish ladders at dams downstream of Link River, salmon and steelhead will return to hold, spawn, and rear in habitat where they were present historically (Hamilton et al. 2005). However, the progeny of these fish must also negotiate not only the reservoir but the dam, powerhouse, and spillway during their outmigration. Unless protected by fish screens and bypasses, both resident and anadromous fish can suffer injury or death by passing through turbines at hydroelectric plants (Electric Power Research Institute 1987). Turbine-caused mortality can have serious consequences for fish populations, especially among anadromous species (Cada 2001). Survival of juvenile salmonids passing dams during their seaward migration is highest through spillways and lowest through turbines (Muir et al. 2001); turbine mortality being caused by pressure changes, cavitation, shear stress, turbulence, strike, and grinding (Cada 2001). The Electric Power Research Institute (Electric Power Research Institute 1987) reported that Francis turbines, which are used at the Applicant’s Eastside and Westside developments, have an average mortality of about 24 percent. It is estimated that “several tens of thousands of resident fish” are annually entrained at “each of the Projects” facilities (ALJ Decision at 28, FOF 4-2). It is anticipated that annual entrainment of anadromous fish would be on the same order of magnitude, if not greater. Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10 to 30 percent (ALJ Decision at 29, FOF 4-5). Based upon these studies and findings, turbine similarities, and known entrainment, the Services conclude that turbine entrainment at the Applicant’s Eastside and Westside developments causes comparable levels of mortality to downstream migrating fish as found in studies cited above. Volitional fish passage would be consistent with fish movement through the

Klamath River system for purposes such as spawning, rearing, feeding, and seasonal use of habitat. Volitional fish passage would be consistent with the goals and objectives for resource management of the Klamath River Basin Fishery Task Force and the Services. Downstream fishways at the Applicant's Eastside and Westside developments would screen and divert both resident and anadromous fish from turbine intakes. This would guide downstream migrating fish, minimize mortality of federally listed suckers, and ensure that delay and entrainment mortality of redband trout, other resident species, and anadromous outmigrants would be minimized. To ensure that these fish can outmigrate, downstream passage facilities at the Eastside and Westside developments are necessary.

Temporary, seasonal trap and transport for downstream migrants would be necessary due to seasonal water quality problems in Lake Ewauna and Keno Impoundment. During most years, the Lake Ewauna reach of the Klamath River (Link River Dam to Keno Dam) has dissolved oxygen concentrations less than 6 mg/L and temperatures greater than 20oC from mid-June through mid- November (Jason Cameron, Reclamation, pers. comm.). While there is evidence that some juvenile Chinook salmon can tolerate temperatures near 20oC in Upper Klamath Lake (Maule et al. 2007), these conditions are not within criteria (U.S. Environmental Protection Agency 2003) for outmigrating juvenile anadromous salmonids and may not be conducive to downstream migration during this period. Transporting outmigrant anadromous salmonids around Keno Impoundment during this period would avoid poor water quality during summer months until restoration efforts improve reservoir dissolved oxygen and water temperatures.

The Services expect that the major outmigrations of juvenile Chinook salmon would occur from March to June for spring-run Chinook and February to May for fall-run juveniles. The Services expect trap and haul to be an effective interim, seasonal fish passage method for Chinook salmon under these summer conditions because only this species would be transported for a short distance. Other species need volitional fishways to access habitat in Keno Impoundment\Lake Ewauna and Link River year round. Seasonal trap and haul would be performed on an interim basis. Water quality is expected to improve over the term of a new Project license through the implementation of the Total Maximum Daily Load (TMDL) process, imposition of state water quality certification conditions, and provisions of a new license (the inclusion of 10(j) recommendations).

Migrating suckers make use of habitat in Lake Ewauna as long as water quality is adequate (i.e., outside of July, August, September (Rich Piaskowski, Reclamation, pers. comm.)). Downstream migrating suckers captured during periods when water quality is inadequate in Keno Impoundment\Lake Ewauna would be returned to Upper Klamath Lake.

Eastside and Westside Tailrace Barrier Prescription Rationale: These developments have no tailrace barriers and have never been tested for mortality to federally listed suckers, other resident fish, or anadromous salmonids. Water discharging from the Eastside and Westside powerhouses represents a significant portion of the total river flow of the Klamath River. The natural tendency for fish attracted to such an area is to hold and wait for passage conditions to improve, or to attempt to move past the obstacle either by swimming or leaping. Depending on powerhouse operations, draft tube discharge velocities at Project facilities are between 3.4 and 10.4 feet per second (fps) (CH2MHill 2006); these velocities easily fall within the swimming abilities of salmonids (Weaver 1963). The types of injury sustained by some fish entering draft tubes or contacting turbines vary from site to site, as do immediate and delayed mortality rates. Several studies, however, attribute injuries in migrating salmonids to powerhouse structures associated with tailrace structures (Department of Fisheries Canada 1958; International Pacific Salmon Fisheries Commission 1976; Schadt et al. 1985; Williams 1985).

Adult anadromous fish are attracted into oncoming flows (National Marine Fisheries Service 2004). Migration upstream may be delayed when tailrace flows from the powerhouse exceed river bypass reach flows. A migration delay, or combined delays at several facilities, may prevent fish from reaching suitable spawning habitat when they are ready to spawn or conditions are optimal for survival. Migration delays caused by tailrace effects may have a greater impact on fish populations than injury and mortality from turbine impacts (Federal Energy Regulatory Commission 1994). Migration delays may occur to a greater percentage of migrating fish than the percentage of fish impacted by turbine mortality.

Migration delays are well documented for anadromous salmonids in the Pacific Northwest (Haynes and Gray 1980; Rondorf et al. 1983; Schadt et al. 1985; Vogel et al 1990). For migratory fish, false attraction occurs when upstream migrants are attracted to turbine discharge or spillway flows rather than to fishway flows. False attraction also occurs when upstream migrants detect the scent of their natal stream downstream of its natural outlet (Fretwell 1989). This happens when water from a natal stream is diverted through a canal or pipe to a hydroelectric project. In either instance, without proper Project design or operation modifications, there may be migratory delays. In order to prevent injury, delay, or mortality to suckers and salmonids, caused by attempts to swim upstream into the tailraces, barriers are required to guide migrating fish away from the tailrace area to continue their upstream migration. The 3 year construction timeline is necessary to meet resource goals and objectives as quickly as possible.

In the Preliminary Prescriptions, the Services based specific tailrace barrier prescriptions on the evidence cited above. In its request for hearing on disputed issues of material fact, the Applicant disputed facts supporting the tailrace barrier prescriptions. The Applicant subsequently withdrew its request for hearing regarding tailrace barrier prescriptions based on a stipulation with the Services (In the Matter Of: Klamath Hydroelectric Project, Docket Number 2006- NMFS-0001, Order Granting the Applicant's Motion to Withdraw USFWS/NMFS Issues 5 and 9, September 14, 2006 (Administrative Law Judge 2006b)). In accordance with the stipulation, the Services have revised the tailrace barrier prescriptions in the Modified Prescriptions below to allow the Applicant to study the need for and design of tailrace barrier s for anadromous and native resident fish. The Applicant must perform any such studies in consultation with the Services, and provide the results of any such studies to the Services for approval before design and construction of the tailrace barriers in order to inform the need for and design of tailrace barriers. However, unless and until such site-specific studies are done, the Services must rely on the available information concluding that tailrace barriers are necessary for the safe, timely, and effective upstream passage of fish at the Eastside and Westside developments.

8.1 Eastside and Westside Downstream Fishways

8.1.1 *Intake Fish Screens and Bypass Facilities*: The Licensee shall construct, operate, maintain, and evaluate fish screens and bypass facilities at both Eastside and Westside developments to provide for the safe, timely, and effective downstream passage of Chinook salmon, steelhead trout, Pacific lamprey, federally listed suckers, and redband trout. The fish screens and bypass facilities shall be located as close as is practicable to the beginning of each diversion to minimize entrapment in the diversion canals. The fish screens and bypass facilities shall transport fish to holding, sorting, counting, and tagging facilities. Fish would then continue through the bypass facility downstream except during the period from June 15 and November 15, when trap and haul downstream to below Keno Dam would be employed for the purposes of restoration and the safe, effective, and timely passage of fish. If agreed to by the Services, seasonal trap and haul downstream shall be discontinued and fish routed downstream through the bypass when dissolved oxygen concentrations are greater than 6 mg/L and temperatures lower than 15°C, as measured at Miller Island using a method that is acceptable to the Services. The bypass facilities shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology), including features to detect and record data from fish tagged above the facilities to evaluate survival and fishway effectiveness. The downstream fishway shall be operated year-round regardless of trap and haul operations to allow for the passage of steelhead, redband trout, lampreys, suckers, and other species. The screens and bypass facilities shall be operated year-round and shall be designed in accordance with sucker criteria (Table 2 in Preliminary Prescription), or alternative criteria as acceptable to the Services. The screens and bypass facilities shall provide for the uninterrupted passage of fish over the full range of river flows for which the Project maintains operational control. The construction shall include features to return suckers to Upper Klamath Lake. The downstream fishways shall be constructed and operational within 3 years of the issuance of the new license.

8.1.2 *Design Consultation*: The Licensee shall develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 above within 1 year of the issuance of the new license for review and approval by the Service and NMFS Engineering. The design of the bypass facilities shall include features to detect and record data for PIT-tagged downstream migrating fish (or fish identified using similar technology) and to hold, sort, count, and mark downstream migrating anadromous fish by age and species. The facilities shall include features to detect and record data from fish tagged above the facilities to evaluated survival and fishway effectiveness. The design shall include features to accomplish the transfer of these fish downstream between June 15 and November 15 for the purposes of restoration and the safe, effective, and timely passage of fish. The design shall include features to return suckers to Upper Klamath Lake. Facilities shall be designed so that fish to be trapped and hauled are held a maximum of 8 hours before transport.

8.1.3 *Monitoring, Reporting, and Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

8.2 Tailrace Barriers at Eastside and Westside Developments

8.2.1 *Tailrace Barrier Construction*: Unless the Services determine, based on site-specific studies, that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 8.2.2 and 8.2.3, the Licensee shall construct a tailrace barrier and guidance system at the Eastside and Westside powerhouses to provide for the safe, timely, and effective upstream passage of Chinook salmon, steelhead trout, suckers, redband trout, and lamprey. The tailrace barriers and guidance system shall be constructed according to approved design plans and within 3 years of the issuance of the new license.

8.2.2 *Tailrace Barrier Studies*: The Licensee may, in consultation with the Services, study the need for and design of a tailrace barrier and guidance system at Eastside and Westside Developments. The Licensee shall submit a plan for any such studies to the Services for review and approval prior to conducting studies. After approval of any such plan, the Licensee shall complete the studies and submit study results and recommendations on the need for and design of tailrace barriers for review and approval by the Services consistent with the provisions for timing of the tailrace barrier design under Modified Specific Prescriptions 8.2.3.

8.2.3 *Tailrace Barrier Design*: Unless the Services determine based on site-specific studies that tailrace barriers are unnecessary in accordance with Modified Specific Prescriptions 8.2.2, the Licensee shall, within 1 year of the issuance of the new license, develop design and construction plans according to the terms of the Modified General Prescriptions 1.1.1 for review and approval by the Service and NMFS Engineering prior to construction.

8.2.4 *Tailrace Barrier Evaluation*: The Licensee shall complete reporting, monitoring, and evaluation of this facility as specified in Modified General Prescriptions, above.

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United States Department of the Interior, Modified Terms and Conditions and Prescriptions for Fishways Filed Pursuant to Sections 4(e) and 18 of Federal Powers Act with the Federal Energy Regulatory Commission for the Klamath River Hydroelectric Project, Project NO. 2082 Klamath River, Siskiyou County, California; and Klamath County, Oregon.

U.S. Department of the Interior Modified 4(e) Conditions – BLM Reservation

BLM Modified Condition 1: Activities on or Affecting Bureau of Land Management-Administered Lands

(a) For any proposed activity to be implemented by the Licensee on or affecting BLM administered lands that are added to the Project boundary, the Licensee shall request and obtain a BLM use authorization prior to conducting the activity. The Licensee shall fund any required environmental analysis related to the issuance of the use authorization, as determined by the BLM. As part of the request for the use authorization, the Licensee may provide environmental analysis of the proposed action that meets BLM requirements for implementing the National Environmental Policy Act (NEPA) in existence at the time the request is made, including changes in statutes or regulations governing BLM NEPA procedures. The Licensee may also refer to or rely on any previous NEPA analysis for the proposed measure to the extent the analysis is currently applicable, as determined by BLM. The use authorization may contain stipulations for fire protection, spoils disposal, hazardous materials, safety or other standard use authorization measures consistent with the requirements in effect at the time for implementation of similar actions on BLM-administered land.

(b) The Licensee shall prepare site-specific plans for the approval of the BLM for activities required by the license that have the potential to impact BLM administered lands or resources. The site-specific plans shall include, at a minimum:

(i) a map depicting the location of the proposed activity;
(ii) the land use allocation and management designation including standards and guidelines for the area of the proposed activity;
(iii)site-specific designs for the proposed activity;
(iv) proposals for Project-specific mitigation measures, including, but not limited to, applicable measures addressing safety, inspections, spoils disposal, hazardous substances, and restoration needs;
(v) proposals for implementation and effectiveness monitoring necessary to meet standards and guidelines; and
(vi) data from surveys, biological evaluations, or consultation required by regulation and as applicable to activities on BLM-administered lands.

(c) Upon BLM approval of the site-specific plans, the Licensee shall conduct any additional environmental analysis deemed necessary by the BLM to ensure consistency with statutes, regulations and policies, including the National Historic Preservation Act (NHPA), the Archaeological Resources Protection Act (ARPA), the Native American Grave Protection Act (NAGPRA), the Clean Air Act, the Clean Water Act, and the Endangered Species Act (ESA) and the BLM direction in the National Environmental Policy Act Handbook 1790-1 (USDI BLM 1988), or as amended. As part of the site-specific plan, the Licensee may provide environmental analysis of the proposed

activity that meets BLM requirements for implementing the National Environmental Policy
Act (NEPA) in existence at the time the request is made. The Licensee may also refer to or rely on any previous site-specific NEPA analysis for the proposed activity to the extent the analysis is currently applicable, as determined by BLM. The Licensee shall obtain written authorization of the BLM prior to the implementation of the activity.

(d) The Licensee shall avoid disturbance to all public land survey monuments, private property corners, and BLM boundary markers. In the event that any markers or monuments are destroyed by an act or omission of the Licensee, in connection with the use and/or occupancy authorized by the license or a BLM use authorization, depending on the type of monument destroyed, the Licensee shall reestablish or reference same in accordance with (1) the procedures outlined in the "Manual of Instructions for the Survey of the Public Land of the United States," (2) the specifications of the County Surveyor, or (3) the specifications of the BLM. The Licensee shall ensure that any such official survey records affected are amended as provided for by law.

(e) The Licensee shall maintain Project-related improvements and facilities located on BLM-administered lands to accepted standards of repair, orderliness, neatness, sanitation, and safety. The Licensee shall comply with all applicable Federal, State, and local laws, regulations, including but not limited to, the Federal Water Pollution Control Act, 33 U.S.C. § 1251 et seq., the Resources Conservation and Recovery Act (RCRA), 42 U.S.C. § 6901 et seq., the Comprehensive Environmental Response, Control, and Liability Act (CERCLA), 42 U.S.C. § 9601 et seq., and other relevant environmental laws, as well as public health and safety laws and other laws relating to the siting, construction, operation, and maintenance of any facility, improvement, or equipment.

(f) The Licensee shall restore BLM-administered lands affected by the Project to a condition satisfactory to BLM prior to any surrender of the Project license. At least one year in advance of license surrender, the Licensee shall file with the Commission a restoration plan approved by the BLM. The plan shall identify Project-related improvements to be removed, restoration measures, and time frames for implementation and estimated restoration costs.

(g) Prior to the abandonment of any Project-related facilities on or affecting BLM administered lands, including impacts due to changes in the Project boundary from that in the original license, the Licensee shall restore such lands and improvements to a condition acceptable to BLM. At least one year in advance of the abandonment of these Project-related facilities, the Licensee shall file with the Commission a restoration and maintenance plan approved by the BLM. The plan shall identify, at a minimum, improvements that will be removed, improvements abandoned but not removed, restoration and maintenance measures, time frames and costs.

(h) The Licensee shall, within one year of license issuance, develop a standard operating procedures plan that the Licensee shall implement in the event of Project-related emergencies. At a minimum, the plan shall address BLM administered lands potentially affected by the Project, and address procedures, environmental permits, and subsequent mitigation measures for any Project related impacts to BLM administered lands including, but not limited to, the J.C. Boyle emergency spillway and canal and slope failures. This plan shall be developed with consultation and approval by BLM. The plan shall include implementation strategies for agency coordination, restoration actions, monitoring and evaluation, and potential mitigation measures.

(i) The Licensee shall exercise diligence in protecting from damage the land and property of the BLM covered by and used in connection with this license, including any buildings, bridges, roads, trails, lands or other property of the BLM; and shall restore, reconstruct or compensate the BLM for any damage resulting from negligence and from the violation of the terms of this license or any law or regulation applicable to the BLM by the Licensee, or by any agents or employees of the Licensee acting within the scope of their agency or employment. Arrangements to restore, reconstruct, or compensate for damages shall be made with the BLM.

(j) The Licensee shall indemnify, defend, and hold the United States harmless for any costs, damages, claims, liabilities, and judgments arising from past, present, and future acts or omissions of the Licensee in connection with the use and/or occupancy of BLM-administered lands or resources authorized by the license. This indemnification and hold harmless provision applies to any acts and omissions of the Licensee or the Licensee's heirs, assigns, agents, employees, affiliates, subsidiaries, fiduciaries, contractors, or lessees in connection with the use and/or occupancy authorized by this license which result in: (1) violations of any laws and regulations which are now or which may in the future become applicable, and including but not limited to environmental laws such as the CERCLA, RCRA, Oil Pollution Act, Clean Water Act, Clean Air Act; (2) judgments, claims, demands, penalties, or fees assessed against the United States; (3) costs, expenses, and damages incurred by the United States; or (4) the release or threatened release of any solid waste, hazardous substances, pollutant, contaminant, or oil in any form in the environment.

BLM Modified Condition 2: Consultation with the Bureau of Land Management

A. The Licensee shall consult with the Bureau of Land Management (BLM) at least annually and prepare a report on the status of implementing conditions of the license, including, at a minimum, those that may affect BLM-administered lands and resources. The report shall include, but is not limited to, the:

1. Results of any monitoring preformed over the previous year for reporting effectiveness of license requirements;
2. Review of any non-routine maintenance;
3. Discussion of any foreseeable changes to Project facilities or operations;
4. Discussion of any necessary revisions or modification to plans approved as part of this license; and
5. Discussion of elements of current year maintenance plans, e.g. road maintenance.

B. A copy of the records, plan reports, monitoring reports, and other pertinent records shall be provided to the BLM at least 10 days prior to the annual meeting, unless otherwise agreed.
C. Within 60-days of issuance of the report to BLM, the Licensee shall file the record of consultation and any BLM comments and recommendations with the Commission.
D. The Licensee shall consult with the BLM on a as-needed basis to identify and resolve potential conflicts with BLM policy and direction prior to initiating activities on BLM-administered lands,
E. The Licensee shall consult with the BLM at least annually to determine if any Project related activity may affect other authorized activities on BLM-administered lands in the Project area. If a Project-related activity may affect other authorized uses, then the Licensee shall resolve potential conflicts with representatives of those permitted uses. The Licensee shall submit copies of other reports related to Project safety, including Spill Prevention Control and Countermeasure Plans and annual emergency and hazardous chemical inventories, and non-compliance to the BLM concurrently with submittal to the Commission. These include, but are not limited to, any non-compliance report filed by the Licensee for facilities or operations on or affecting BLM-administered lands.

BLM Modified Condition 3: Roads Inventory Analysis and Roads Management
A. Within six months of license issuance, the Licensee shall complete, in consultation with the Bureau of Land Management (BLM), a Project Roads Inventory Analysis (Analysis) and file the Analysis with the Commission for approval. The Licensee shall prepare a draft Analysis after consultation with the BLM. The Licensee shall allow a minimum of 60 days for the BLM to comment and make recommendations on the draft Analysis before finalizing the Analysis and filing it with the Commission. The Licensee shall include with the Analysis documentation of consultation, copies of comments and recommendations and a description of how the comments and recommendations are accommodated by the Analysis. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project specific information. At the time it files the Analysis with the Commission, the Licensee shall serve a copy of the filed documents upon the BLM. At a minimum, the Analysis shall address all roads that cross BLM-administered lands included within the geographical scope of the *Study Area Roadway Inventory Analysis and Project Roadway Management Plan – Klamath Hydroelectric Project (FERC Project No. 2082)* (PacifiCorp 2004m), including in the analysis the estimated percentage of use that is associated with Project operations and maintenance and other Project-related activities such as Project-related recreation. The Analysis, at a minimum, shall identify and map the roads, bridges, culverts and other transportation-related structures within the broader overall study area, as described above, as well as identifying the estimated percentage of Project-related use these transportation-related facilities sustain.

B. Within one year of license issuance, the Licensee shall develop, in consultation with the BLM, a Road Management Plan (Plan) and file the Plan with the Commission for approval. The Licensee shall prepare a draft Plan after consultation with the BLM.
The Licensee shall allow a minimum of 60 days for the BLM to comment and make recommendations on the draft Plan before finalizing the plan and filing it with the

Commission. The Licensee shall include with the Plan documentation of consultation, copies of comments and recommendations and a description of how the comments and recommendations are accommodated by the Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project specific information. At the time it files the Plan with the Commission, the Licensee shall serve a copy of the filed documents upon the BLM. The Plan shall include all roads that cross BLM-administered lands (BLM Roads) that are identified in the Project Roads Inventory Analysis that sustain Project-related uses, including Project related recreation.

1. At a minimum, the Plan shall include the items specified in the Final License Application (PacifiCorp 2004a, Executive Summary, page 8-5; Land Use, Visual, and Aesthetic Resources Final Technical Report, page 3-7; and Appendix 3C) and shall:

    (a) Identify roads, bridges, culverts and other transportation-related structures necessary for Project-related activities, including Project-related recreation;
    (b) Identify transportation-related operations and maintenance (O&M) activities required for the continued operation of the Project;
    (c) Identify transportation-related activities required to address Project-related recreation uses;
    (d) Include provisions for use and cost-sharing agreements for Project and Project-related transportation related structures;
    (e) Identify the Licensee share for management and maintenance of BLM Roads affected by the Project;
    (f) Identify BLM roads previously used but which are no longer necessary to operate and maintain the Project or used for Project-related recreation, and include plans for decommissioning these roads as appropriate;
    (g) Provide for continued protection of natural and cultural resources along Project-related roadway corridors;
    (h) Identify appropriate standards for the maintenance of Project-related roads and other transportation-related structures;
    (i) Identify and implement Best Management Practices for maintaining and protecting cultural resources, vegetation resources (including management for noxious weeds), aquatic resources, and minimizing soil erosion; and
    (j) Identify relevant BLM policies for transportation management of BLM Roads affected by Project-related activities.

2. The Roads Plan shall accommodate unrestricted access by the BLM necessary to manage and administer BLM lands and resources that are affected by Project operations. The plan shall include provisions for the maintenance of crossings and rights-of-way (ROW) required by and consistent with permit requirements for powerlines, penstocks, ditches, and pipelines.

C. The Licensee shall consult with the BLM prior to erecting any signs on BLM administered lands that are necessary for operation or maintenance of Project operations or facilities. The Licensee must obtain approval from the BLM specific to the location, design, size, color, and content of signs. The Licensee shall be responsible for maintaining all Licensee-erected signs to neat and presentable standards.

BLM Modified Condition 4: River Corridor Management

A. J.C. Boyle Bypassed River Reach

1. Required Minimum Streamflows – The Licensee shall, within one year after license issuance, operate J.C. Boyle Development to accomplish the following:

(a) Proportional flow requirement: Provide no less than 40% of the inflow to J.C. Boyle Reservoir to the J.C. Boyle Bypassed River Reach, to be measured at a new gage below the J.C. Boyle Dam near RM 225. Inflow to J.C. Boyle Reservoir shall be calculated by averaging the previous three days of the combined daily flows as measured at the Keno gage #11509500 and Spencer Creek gage #11510000 (Calculated Inflow).

(b) Minimum base flow requirement: When Calculated Inflow is less than 1,175 cubic feet per second (cfs), no less than 470 cfs shall be provided to the J.C. Boyle Bypassed River Reach, except that when the Calculated Inflow is less than 470 cubic feet per second (cfs), then flow shall be provided to the J.C. Boyle Bypassed River Reach in an amount equal to the Calculated Inflow.

(c) Seasonal high flow requirement: When Calculated Inflow to J.C. Boyle Reservoir exceeds 3,300 cfs during the period between February 1st and April 15th, diversion to the J.C. Boyle Power Canal shall be suspended at least once and continued for a minimum of seven days.

2. Ramping During Controlled Events – The Licensee shall, within one year after license issuance, operate J.C. Boyle Development to not exceed an up-ramp rate or down-ramp rate of two inches per hour as measured at the new gage below J.C. Boyle Dam when conducting controlled flow events (e.g., scheduled maintenance and changes in minimum flow requirements), except when implementing the seasonal high flow or when turbine capacity is exceeded. The Licensee, in consultation with the BLM, shall develop and implement an appropriate ramp rate to follow after the seasonal high flow to prevent stranding fish in the J.C. Boyle Bypassed Reach.

B. J.C. Boyle Peaking Reach

1. Streamflow Requirements – The Licensee shall, within one year after license issuance, operate the J.C. Boyle Development from May 1st to October 31st to provide a minimum streamflow of 1,500 cfs a maximum of once a week, such that these flows occur at the Spring Island Boat Launch between 0900 and 1400 hours from Friday through Sunday, in the priority of Saturday, Sunday, and then Friday.

2. Ramping During Controlled Events – The Licensee shall, within one year after license issuance, operate the J.C. Boyle development to not exceed an up-ramp rate or down-ramp rate of two inches per hour when conducting controlled flow events (e.g. scheduled maintenance, power generation, changes in streamflow

requirements), except during implementation of the seasonal high flow, as measured at the J.C. Boyle Powerhouse gage USGS #11510700.

3. Flow Continuation Measure – The Licensee shall, within one year of license issuance, implement a flow continuation measure at the J.C. Boyle canal and powerhouse to provide a minimum of 48 hours of continuous flow under powerhouse shutdown conditions.

C. Streamflow Measurement and Reporting: J.C. Boyle Bypassed River and Peaking Reaches

1. Instream Flow Measurement – The Licensee shall, within one year after license issuance:

   (a) Continuously measure the stage of water at three existing gage sites. Existing gage stations shall include the Klamath River below Keno Dam (#11509500), Spencer Creek above the confluence with the J.C. Boyle Reservoir (#11510000), and Klamath River below the J.C. Boyle Powerhouse (#11510700). The Licensee shall operate and maintain the gages at these sites if the gages are no longer operated or maintained by the current operators.

   (b) The Licensee shall establish and operate one additional gage on the Klamath River J.C. Boyle Bypassed River Reach below all outlets from the J.C. Boyle Dam and above the springs near RM 225, using the most current USGS protocol for gage station installation, maintenance, and data collection.

2. Instream Flow Reporting - The Licensee shall, within one year after license issuance:

   (a) Provide instantaneous 30-minute real time streamflow data in cfs via remote access that is readily available and accessible to the public.

   (b) Design and maintain a database, similar to the most current version of the USGS National Water Information System (NWIS) for reporting on surface water. The database shall store gage network data and streamflow tracking procedures. BLM shall review and approve the database.

3. The Licensee shall, within two years after license issuance, submit a report for each water year (i.e. October 1st through September 30th) of streamflow data reported in cfs to the BLM. The report shall be filed with the BLM within six months of the end of each water year.

U.S. Department of Interior Modified 4(e) Conditions – Reclamation Reservation

1) The Licensee shall enter into new or amended contract with Reclamation for the operation and maintenance of Link River and Keno Dams under terms and conditions satisfactory to the Secretary of the Interior. Such terms shall be substantially similar to the terms of the current contract and shall specifically include the following terms necessary for the protection of Klamath Reclamation Project operations:

a. The Licensee shall continue to operate and maintain Link River Dam. Such operation shall be consistent with the Klamath Reclamation Project Annual Project Operations Plans.

b. For the period of the contract the Licensee would agree to furnish electric power for the purposes of pumping Klamath Water for use on Project Land and for drainage of Project Land at rates no higher than the cost of service from Project 2082.

c. The Licensee shall, at its own expense, maintain the approach channel to the "A" Canal of the Klamath Reclamation Project to the satisfaction of Reclamation so far an may be necessary to carry a flow of not less than 1200 cfs into the "A" Canal with the water of Upper Klamath Lake at an elevation of 4137 (USBR datum).

d. The Licensee shall assume any and all liability for damages resulting from operation of the Link River Dam by the Licensee or resulting from its regulation and control of the water levels of Upper Klamath Lake. The Licensee would undertake to hold the United States harmless from any and all liability for damage arising out of the operation by the Licensee of Link River Dam and the regulation and control by the Licensee of Upper Klamath Lake provided for in the contract.

e. Nothing in the contract shall curtail or in anywise be construed as curtailing the rights of the United States to Klamath Water or to the lands along or under the margin of Upper Klamath Lake. No Klamath water shall be used by PacifiCorp when it may be needed or required by the United States or any irrigation or drainage district, person, or association obtaining water from the United States for use for domestic, municipal, and irrigation purposes on Project Land.

f. PacifiCorp shall operate Keno Dam so that the upstream water level will not be below the minimum normal objective operating height of elevation 4085.0 (USBR Datum), at or near the location of the present Highway No. 66 bridge at Keno, Oregon.

g. PacifiCorp shall operate Keno Dam to accommodate the discharge of three thousand (3,000) cubic feet per second from the Lost River Diversion Channel, and six hundred (600) cubic feet per second from the Klamath Straits Drain.

2) The Licensee, in consultation with Reclamation, shall develop operating criteria that provides for coordination with the operations of Link River Dam and Iron Gate Dam, or the most downstream dam within Project No. 2082 to allow Reclamation to meet its responsibilities.

3) The Licensee, in consultation with Reclamation, shall develop operating criteria that provides for coordination with the operations of Keno Dam and Iron Gate Dam, or the most downstream dam within Project No. 2082, as in Attachment 2.
4) The Licensee shall provide Reclamation with area capacity curves for all facilities within Project No. 2082, and will provide Reclamation with real time access to reservoir elevations and releases for facilities within Project No. 2082.
5) Any operations or modifications to Project No. 2082 that could affect the federal Klamath Reclamation Project are prohibited unless approved by Reclamation.
6) The licensee shall have no claim against the United States arising from the effect of any changes in releases from, operations of, or elevation changes in Upper Klamath Lake or Lake Ewauna related to the Reclamation's Klamath Project operations or use of water for the Upper Klamath, Lower Klamath or Tule Lake National Wildlife Refuges.
7) Authority is reserved to the Commission to require the Licensee to implement such conditions for the protection and utilization of Reclamation reservations as may be provided by the Secretary of the Interior, pursuant to Section 4(e) of the Federal Power Act, 16 U.S.C. § 797(e).

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Appendix B
Standard Operating Procedures and Best Management Practices Common to the Action Alternatives

B.1 Water Quality

B.1.1 Water Quality Impacts from Deconstruction/Construction and Restoration Activities

Short-term effects on water quality from deconstruction, construction and restoration activities associated with dam removal alternatives, fish ladder construction associated with fish passage alternatives, and restoration activities associated with Klamath Basin Restoration Agreement (KBRA) implementation (i.e., Phase 1 and 2 Fisheries Restoration Plans, the Agency Lake and Barnes Ranches Project, and the Wood River Wetland Restoration Project), would occur. These effects would include increased sediment and turbidity from deconstruction and/or construction activities (e.g., clearing/grading/excavating, demolition and debris disposal, material delivery and storage, revegetation) and inorganic and organic contaminants from hazardous materials associated with construction equipment (i.e., fuels, oils, lubricants) entering nearby or adjacent water bodies.

For all deconstruction and/or construction related activities and restoration projects impacts could be mitigated through the implementation of standard pollution prevention measures as part of project design specifications and standard construction practices. Briefly, these measures would include the following:

- Storm water erosion and sediment control measures for all deconstruction and/or construction activities;
- Proper control of non-stormwater discharges; and,
- Hazardous spill prevention and response measures.

B.1.1.1 Storm Water Pollution Prevention Plan

A Storm Water Pollution Prevention Plan (SWPPP) would be prepared and implemented during and after deconstruction and/or construction activities and would include an erosion control and restoration plan for each construction site, a water quality monitoring plan, a hazardous materials management plan, and post-construction best management practices (BMPs). The SWPPP would be prepared by a Qualified SWPPP Developer and submitted prior to project initiation and as part of project permitting. The SWPPP would be implemented by the Qualified SWPPP Developer or a Qualified SWPPP Practitioner. All BMPs would be maintained until areas disturbed during deconstruction and/or construction have been adequately revegetated and stabilized. For restoration activities associated with KBRA implementation, specific BMPs should be addressed in the project-level National Environmental Policy Act (NEPA) evaluations conducted for each project.

B.1.1.2 Measures to Minimize Disturbance from Instream Construction

Other measures to minimize disturbance associated with instream construction activities are presented below. Measures are excerpted from Measures to Minimize Disturbance from Construction, on page IX-50 of the California Department of Fish and Game (CDFG) Manual.

- If the stream channel is seasonally dry between June 15 and November 1, construction will occur during this dry period.
- Debris, soil, silt, excessive bark, rubbish, creosote-treated wood, raw cement/concrete or washings thereof, asphalt, paint or other coating material, oil or other petroleum products, or any other substances which could be hazardous to aquatic life, resulting from projected related activities, shall be prevented from contaminating the soil and/or entering the waters of the State. Any of these materials, placed within or where they may enter a stream or lake, by the applicant or any party working under contract, or with permission of the applicant, shall be removed immediately. During project activities, all trash that may attract potential predators of salmonids will be properly contained, removed from the work site, and disposed of daily.
- Where feasible, the construction shall occur from the bank, or on a temporary pad underlain with filter fabric.
- No mechanized equipment (e.g. internal combustion hand tools), will enter wetted channels.
- Use of heavy equipment shall be avoided in a channel bottom with rocky or cobbled substrate. If access to the work site requires crossing a rocky or cobbled substrate, a rubber tire loader/backhoe is the preferred vehicle. Only after this option has been determined infeasible will the use of tracked vehicles be considered. The amount of time this equipment is stationed, working, or traveling within the creek bed shall be minimized. When heavy equipment is used, woody debris and vegetation on banks and in the channel shall not be disturbed if outside of the project’s scope.
- All mechanized equipment working in the stream channel or within 25 feet of a wetted channel shall have a double containment system for diesel and oil fluids. Hydraulic fluids in mechanical equipment working within the stream channel shall not contain organophosphate esters. Vegetable based hydraulic fluids are preferred.

- The use or storage of petroleum-powered equipment shall be accomplished in a manner to prevent the potential release of petroleum materials into waters of the state (Fish and Game Code 5650).
- Areas for fuel storage, refueling, and servicing of construction equipment must be located in an upland location.
- Prior to use, clean all equipment to remove external oil, grease, dirt, or mud. Wash sites must be located in upland locations so wash water does not flow into the stream channel or adjacent wetlands.
- All construction equipment must be in good working condition, showing no signs of fuel or oil leaks. Prior to construction, all mechanical equipment shall be thoroughly inspected and evaluated for the potential of fluid leakage. All questionable motor oil, coolant, transmission fluid, and hydraulic fluid hoses, fitting, and seals shall be replaced. The contractor shall document in writing all hoses, fittings, and seals replaced and shall keep this documentation until the completion of operations. All mechanical equipment shall be inspected on a daily basis to ensure there are no motor oil, transmission fluid, hydraulic fluid, or coolant leaks. All leaks shall be repaired in the equipment staging area or other suitable location prior to resumption of construction activity.
- Oil absorbent and spill containment materials shall be located on site when mechanical equipment is in operation with 100 feet of the proposed watercourse crossings. If a spill occurs, no additional work shall commence in-channel until (1) the mechanical equipment is inspected by the contractor, and the leak has been repaired, (2) the spill has been contained, and (3) CDFG and National Oceanic and Atmospheric Administration (NOAA) Fisheries Service are contacted and have evaluated the impacts of the spill.

B.1.1.3 Measures to Minimize Degradation of Water Quality during Deconstruction, Construction and Restoration Activities

Construction or maintenance activities for the projects covered under this Program may result in temporary increases in turbidity levels in the stream. In general, these activities must not result in significant increases in turbidity levels beyond the naturally occurring, background conditions. The following measures would be implemented to reduce the potential for impacts to water quality during and post-construction:

- General Erosion Control During Construction:
  - When appropriate, isolate the construction area from flowing water until project materials are installed and erosion protection is in place.
  - Effective erosion control measures shall be in place at all times during construction. Do not start construction until all temporary control devices (straw bales with sterile, weed free straw, silt fences, etc.) are in place downslope or downstream of project site within the riparian area. The devices shall be properly installed at all location where the likelihood of sediment input exists. These devices shall be in place during and after construction activities for the purposes of minimizing fine sediment and sediment/water slurry input to flowing water and of detaining sediment-laden water on site. If

continued erosion is likely to occur after construction is completed, then appropriate erosion prevention measures shall be implemented and maintained until erosion has subsided. Erosion control devices such as coir rolls or erosion control blankets will not contain plastic netting of a mesh size that would entrain reptiles (esp. snakes) and amphibians.
  - Sediment shall be removed from sediment controls once it has reached one-third of the exposed height of the control. Whenever straw bales are used, they shall be staked and dug into the ground 12 cm and only sterile, weed free straw shall be utilized. Catch basins shall be maintained so that no more than 15 cm of sediment depth accumulates within traps or sumps.
  - Sediment-laden water created by construction activity shall be filtered before it leaves the right-of-way or enters the stream network or an aquatic resource area.
  - The contractor/project applicant is required to inspect and repair/maintain all practices prior to and after any storm event, at 24 hour intervals during extended storm events, and a minimum of every two weeks until all erosion control measures have been completed.

- Guidelines for Temporary Stockpiling:
  - Minimize temporary stockpiling of material. Stockpile excavated material in areas where it cannot enter the stream channel. Prior to start of construction; determine if such sites are available at or near the project location. If nearby sites are unavailable, determine location where material will be deposited. Establish locations to deposit spoils well away from watercourses with the potential to delivery sediment into streams supporting, or historically supporting populations of listed salmonids. Spoils shall be contoured to disperse runoff and stabilized with mulch and (native) vegetation. Use devices such as plastic sheeting held down with rocks or sandbags over stockpiles, silt fences, or berms of hay bales, to minimize movement of exposed or stockpiled soils.
  - If feasible, conserve topsoil for reuse at project location or use in other areas. End haul spoils away from watercourses as soon as possible to minimize potential sediment delivery.

- Minimizing Potential Scour:
  - When needed, utilize instream grade control structures to control channel scour, sediment routing, and headwall cutting.
  - For relief culverts or structures, if a pipe or structure that empties into a stream is installed, an energy dissipater shall be installed to reduce bed and bank scour. This does not apply to culverts in fish bearing streams.
  - The toe of rock slope protection used for streambank stabilization shall be placed below bed scour to ensure stability.

- Post Construction Erosion Control:
  - Immediately after project completion and before close of seasonal work window, stabilize all exposed soil with mulch, seeding, and/or placement of

erosion control blankets. Remove all artificial erosion control devices after the project area has fully stabilized. All exposed soil present in and around the project site shall be stabilized within 7 days. Erosion control devices such as coir rolls or erosion control blankets will not contain plastic netting of a mesh size that would entrain reptiles (esp. snakes) and amphibians.

- All bare and/or disturbed slopes (> 10' x 10' of bare mineral soil) will be treated with erosion control measures such as hay bales, netting, fiber rolls, and hydroseed as permanent erosion control measures.
- Where straw, mulch, or slash is used as erosion control on bare mineral soil, the minimum coverage shall be 95 percent with a minimum depth of two inches.
- When seeding is used as an erosion control measure, only natives will be used. Sterile (without seeds), weed-free straw, free of exotic weeds, is required when hay bales are used as an erosion control measure.

B.1.2 Land Management Related Water Quality Effects

Adjacent forest, agricultural and urban land use practices may cause temperature extremes, increase turbidity, increase nutrients, suspended solids or toxics, alter salinity and reduce dissolved oxygen. The following best management practices can help reduce effects on water quality due to adjacent land management practices:

- Install fencing to keep livestock out of riparian areas.
- Irrigation tailwater reduction and/or capture projects to manage pasture runoff and reduce nutrient load.
- Construct tailwater wetlands and infiltration ponds to capture runoff from roads, development, farms, and irrigation return flows.
- Enhance the extent and function of wetlands and wet meadows.
- Conduct appropriate shade restoration activities where streamside shading has been reduced by anthropogenic activities.
- Improve upland water infiltration through road decommissioning, reduced soil compaction, direct seeding activities, increasing native vegetation cover.
- Minimize surface water withdrawals (increases stream flow) through implementation of irrigation efficiencies, quantify legal withdrawals, identify and eliminate illegal withdrawals, lease of water rights and purchase of water rights that would not impact agriculture production.

The Proposed Action would include the transfer of PacifiCorp land surrounding the Four Facilities (Parcel B lands) to a state agency. This agency would install fencing around these lands for the purposes of land management. It would prevent cattle access but would allow wildlife to pass. The fence would meet CDFG requirements for wildlife-friendly fencing.

B.2 Aquatic Resources

The best management practices described below are likely to avoid adverse effects to fish and other aquatic resources that could be potentially caused by KBRA fish habitat restoration activities.

B.2.1 Effects on Fish Access and Passage

Road crossings (bridges and culverts), barriers (diversion dams), and unscreened water diversions are causing barriers to spawning and rearing habitat and interrupting adult and juvenile fish passage in many streams within watersheds. Removing barriers addressed limiting and causal factors such as loss of habitat quantity, habitat fragmentation, decreased habitat refugia and diversity, and increased density-dependent mortality from concentrating populations into small habitat units.

- Install bridges or appropriately sized culverts and dish screens consistent with the newest standards and guidelines. Effectively maintain culverts, screens and other instream structures.
- Remove, modify, or replace dams, culverts, diversions, and weirs that prevent or restrict access to salmon, trout, or sucker habitat and/or cause loss of habitat connectivity.
- Construct bypass channels for passage around diversion dams.
- Construct bolder weirs and roughened channels to provide passage a diversions or culverts.
- Establish and provide fish passage flows (eliminate low flow barriers).
- Reduce artificial flow fluctuations to allow or reduce volitional or voluntary movement to other suitable habitats.

B.2.2 Effects on Fish Migration, Spawning and Incubation and Juvenile Rearing

Removal of large woody debris, ditching, diking, bank armoring and gravel removal has the potential to eliminate connectivity between rivers and side channels and off-channel waters, increased speed and volume of stream flows, simplified channel structure, and degraded estuarine and nearshore habitat. The following best management practices can reduce the effects to fish migration, spawning, and incubation and juvenile rearing:

- Restore or reconnect off-channel habitats, disconnected oxbows and wetlands, including spring improvement, enhancement, and reconnection.
- Restore and/or reconnect side-channel habitats, islands, spawning channels, and reconnect back channels to increase large woody debris (LWD) deposition, channel complexity, and riparian areas.
- Re-slope vertical banks and establish wetland habitats by connecting the floodplain with the channel.
- Create diverse channel patterns to enhance water circulation through floodplain gravels.

- Add high quality spawning gravel to channel through a supplementation program.
- Use dike setbacks, removal, breaching, sloping, and/or channel reconnection to connect the channel with the floodplain.
- Increase flood-prone areas to reduce lateral scour and flow volume in main channel and protect or improve existing spawning habitats.
- Restore and reconnect wetlands and floodplains to the riverine system where appropriate.
- Decommission or relocate roads, low-priority dikes, bridges, and culverts to enhance floodplain connectivity.
- Implement setback levees recharge floodplain habitats.
- Identify, protect, and re-establish ground-water sources.
- Remove or replace existing bank stabilization structures (rip rap) and replace with bioengineered structures that allow habitat forming processes.
- Replace invasive or non-native vegetation with native vegetation
- Create or redesign pools, riffles and other habitat features
- Influence or redirect stream flows to reduce erosive forces on stream banks or stream-beds
- Installation of deflectors, barbs and vanes
- Add LWD and place in-channel engineered log jams. Add key pieces of wood to stabilize banks, provide hiding cover, and reestablish natural channel geomorphology.
- Improve riparian habitats by planting native vegetation with the potential to contribute to future LWD recruitment.
- Increase the density, maturity, and appropriate species composition of woody vegetation in riparian buffers for long-term recruitment of LWD.
- Install instream structures such as boulders and rock weirs to increase short-term pool formation and long-term habitat diversity.
- Add rock weirs or boulders to increase channel roughness.
- Install habitat boulders.
- Install instream structures to slow water velocities and increase gravel retention.

B.2.3 Effects on Riparian Areas as Fish Habitat

Riparian areas provide critical habitat elements and functions essential to many fish and wildlife life stages, such as shade, large woody debris, organic nutrients, stream bank stabilization, control of sediments, and filtration of nutrients and pollutants. Much has been removed or altered through logging, grazing, farming and land development. This has eliminated and degraded spawning and rearing habitat for salmonids and suckers and diminished water quantity and quality. The following best management practices can reduce the effects to riparian areas:

B.2.3.1 Minimizing Disturbance

- Install and maintain fencing to prevent livestock access to riparian zones and Streams.

- Manual removal of noxious weeds and replace them with native vegetation (no herbicides).
- Retain as many trees and brush as feasible, emphasizing shade producing and bank stabilizing trees and brush.
- Install Alternative Stock Water Systems or provide off-site watering opportunities.
- Use project designs and access points that minimize riparian disturbance without affecting less stable areas, which may increase the risk of channel instability.
- Prior to construction, determine locations and equipment access points that minimize riparian disturbance. Avoid entering unstable areas. Use project designs and access points that minimize riparian disturbance without affecting less stable areas, which may increase the risk of channel instability.
- Minimize soil compaction by using equipment with a greater reach or that exerts less pressure per square inch on the ground, resulting in less overall area disturbed or less compaction of disturbed areas.
- If riparian vegetation is to be removed with chainsaws, consider using saws currently available that operate with vegetable-based bar oil.
- While encouraged, removal of exotic invasive riparian vegetation in a stream with high temperatures must be done in a manner to avoid creation of additional temperature loading to fish bearing streams. If a stream has a seven day moving average daily maximum (7DMADM) temperature greater than 17.8 Celsius (C) in a coho and steelhead stream or greater than 18.5 C in a steelhead only stream, and vegetation management would reduce overstory shade canopy to the wetted channel, then the practice will not be allowed.

B.2.3.2 Revegetation and Success Criteria

- Any stream bank area left barren of vegetation as a result of the implementation or maintenance of the practices shall be restored to a natural state by seeding, replanting, or other agreed upon means with native trees, shrubs, and/or grasses prior to November 15 of the project year. Barren areas shall typically be planted with a combination of willow stakes, native shrubs and trees and/or erosion control grass mixes.
- Native plant species shall be used for revegetation of disturbed and compacted areas. The species used shall be specific to the project vicinity or the region of the state where the project is located, and comprise a diverse community structure (plantings shall include both woody and herbaceous species).
- For projects where re-vegetation is implemented to compensate for riparian vegetation impacted by project construction, a re-vegetation monitoring report will be required after 5 years to document success. Success is defined as 80 percent survival of plantings or 80 percent ground cover for broadcast planting of seed after a period of 3 years. If revegation efforts will be passive (i.e. natural regeneration), success will be defined as total cover of woody and herbaceous material equal to or greater than pre-project conditions. If at the end of five years, the vegetation has not successfully been re-established, the applicant will be responsible for replacement planting, additional watering, weeding, invasive

exotic eradication, or any other practice, to achieve these requirements. If success is not achieved within the first 5 years, the project applicant will need to prepare a follow-up report in an additional 5 years. This requirement will proceed in 5-year increments until success is achieved.
- All plastic exclusion netting placed around plantings will be removed and recycled after 3 years.
- Restore and reconnect wetlands and floodplains to the riverine system.

B.2.4 Effects of Increased Sediment on Fish

Surrounding land management can cause decreased stability of substrate, banks and channels; high levels of fine sediment; high likelihood of landslides; and increased turbidity. Forest and agricultural practices contribute substantial quantities of sediment to streams and estuaries which can ultimately impact water quality and create effects to fish. The following best management practices can reduce sediment and the effects it can have on fish:

- Remove, reconstruct or upgrade roads that are vulnerable to failure due to design or location.
- Implement a road maintenance schedule to prevent and mitigate sediment impacts.
- Implement road maintenance and decommissioning plans.
- Upgrade stream crossings, culverts and road drainage systems.
- Reconnect floodplains through dike removal or breaching.
- Implement in-channel projects that address geologic processes such as deep-seated slope failure, toe erosion, or landslides.
- Construct infiltration and tailwater ponds to capture runoff from roads, development, farms and irrigation return flow.
- Re-establish natural riparian vegetation to restore a more natural delivery and routing of sediment.

B.2.5 Effects of Stream Flows on Salmonid Life Stages

Low flow conditions can affect salmonid life stages. The problem could be caused by water withdrawals, forest and agricultural practices (e.g., diking, and draining), extent of impervious surfaces, hydropower and reservoir operation, and/or alteration of groundwater recharge areas. The following best management practices can reduce the effects of stream flows on salmonid life stages:

- Installation and maintenance of stream gages/measuring devices.
- Improve baseline instream flows via water efficiency improvements.
- Restore wetlands, reconnect and revegetate floodplains.
- Restore hydrologic connectivity and increase floodwater storage capacity between streams and wetlands and/or floodplains.
- Remove and relocate dikes, levees and other structures.

- Install Alternative Stock Water Systems or provide off-site watering opportunities.
- Reduce diversion amount through irrigation tailwater reduction and/or capture.

B.2.6 Effects of Dewatering Activities on Fish

Project activities authorized under the KBRA may require dewatering activities. Dewatering may not be appropriate for some projects that will result in only minor input of sediment, such as placing logs with hand crews, or installing boulder clusters. Dewatering can result in the temporary loss of aquatic habitat, and the stranding, displacement, or crushing of fish and amphibian species. Increased turbidity may occur from disturbance of the channel bed. The following are general dewatering guidelines and can help reduce potential impacts on fish, for projects that do require dewatering of a stream/creek.

- In those specific cases where it is deemed necessary to work in a flowing stream/creek, the work area shall be isolated and all the flowing water shall be temporarily diverted around the work site to maintain downstream flows during construction.
- Exclude fish from reentering the work area by blocking the stream channel above and below the work area with fine-meshed net or screens. Mesh will be no greater than 1/8 inch diameter. The bottom of the seine must be completely secured to the channel bed to prevent fish from reentering the work area. Exclusion screening must be placed in areas of low water velocity to minimize fish impingement. Screens must be checked periodically and cleaned of debris to permit free flow of water. Block nets shall be placed and maintained throughout the construction period at the upper and lower extent of the areas where fish will be removed. Block net mesh shall be sized to ensure salmonids upstream or downstream do not enter the areas proposed for dewatering between passes with the electrofisher or seine.
- Prior to dewatering, determine the best means to bypass flow through the work area to minimize disturbance to the channel and avoid direct mortality of fish and other aquatic vertebrates. Bypass stream flow around the work area, but maintain the stream flow to channel below the construction site.
- Coordinate project site dewatering with a qualified biologist to perform fish and amphibian relocation activities. The qualified biologist(s) will possess a valid State of California Scientific Collection Permit as issued by the California Department of Fish and Game and will be familiar with the life history and identification of listed salmonids and listed amphibians within the action area.
- Prior to dewatering a construction site, qualified individuals will capture and relocate fish and amphibians to avoid direct mortality and minimize take. This is especially important if listed species are present within the project site.
- Minimize the length of the dewatered stream channel and duration of dewatering.
- Any temporary dam or other artificial obstruction constructed shall only be built from materials such as sandbags or clean gravel which will cause little or no siltation. Visqueen shall be placed over sandbags used for construction of

cofferdams construction to minimize water seepage into the construction areas. The visqueen shall be firmly anchored to the streambed to minimize water seepage. Coffer dams and the stream diversion systems shall remain in place and fully functional throughout the construction period.

- When coffer dams with bypass pipes are installed, debris racks will be placed at the bypass pipe inlet. Bypass pipes will be monitored a minimum of two times per day, seven days a week, during the construction period. All accumulated debris shall be removed by the contractor or project applicant.
- Bypass pipe diameter will be sized to accommodate, at a minimum, twice the summer baseflow.
- The work area may need to be periodically pumped dry of seepage. Place pumps in flat areas, well away from the stream channel. Secure pumps by tying off to a tree or stake in place to prevent movement by vibration. Refuel in an area well away from the stream channel and place fuel absorbent mats under pump while refueling. Pump intakes shall be covered with 1/8 inch mesh to prevent potential entrainment of fish or amphibians that failed to be removed. Check intake periodically for impingement of fish or amphibians.
- If pumping is necessary to dewater the work site, pprocedures for pumped water shall include requiring a temporary siltation basin for treatment of all water prior to entering any waterway and not allowing oil or other greasy substances originating from the contractor or project applicants operations to enter or be placed where they could a wetted channel. Projects will adhere to CDFG's "Fish Screening Criteria" (2000).
- Discharge wastewater from construction area to an upland location where it will not drain sediment-laden water back to the stream channel.
- When construction is completed, the flow diversion structure shall be removed as soon as possible in a manner that will allow flow to resume with the least disturbance to the substrate. Cofferdams will be removed so surface elevations of water impounded above the cofferdam will not be reduced at a rate greater than one inch per hour. This will minimize the risk of beaching and stranding of fish as the area upstream becomes dewatered.

B.2.7 Effects of Relocation Activities on Fish

Project activities authorized under the KBRA may require relocation activities. The below best management practices can help reduce the impacts to fish from relocation activities, considering the difference types of relocation methods.

- Fish relocation and dewatering activities shall only occur between June 15 and November 1 of each year.
- All seining, electrofishing, and relocation activities shall be performed by a qualified fisheries biologist. The qualified fisheries biologist shall capture and relocate listed salmonids prior to construction of the water diversion structures (e.g., cofferdams). The qualified fisheries biologist shall note the number of salmonids observed in the affected area, the number and species of salmonids relocated, and the date and time of collection and relocation. The qualified

fisheries biologist shall have a minimum of three years field experience in the identification and capture of salmonids, including juvenile salmonids, considered in this Biological Assessment. The qualified biologist will adhere to the following requirements for capture and transport of salmonids:

- Determine the most efficient means for capturing fish. Complex stream habitat generally requires the use of electrofishing equipment, whereas in outlet pools, fish may be concentrated by pumping-down the pool and then seining or dip netting fish.
- Notify NOAA Fisheries Service one week prior to capture and relocation of salmonids to
- Provide NOAA Fisheries Service an opportunity to attend (call Shari Anderson at 707-825-5186 or via email at shari.anderson@noaa.gov).
- Initial fish relocation efforts will be conducted several days prior to the start of construction. This provides the fisheries biologist an opportunity to return to the work area and perform additional electrofishing passes immediately prior to construction. In many instances, additional fish will be captured that eluded the previous day's efforts.
- In regions of California with high summer water temperatures, perform relocation activities during morning periods.

- Prior to capturing fish, determine the most appropriate release location(s). Consider the following when selecting release site(s):
  - Similar water temperature as capture location;
  - Ample habitat for captured fish; and,
  - Low likelihood of fish reentering work site or becoming impinged on exclusion net or screen.
- Periodically measure air and water temperatures. Cease activities when measured water temperatures exceed 17.8 C. Temperatures will be measured at the head of riffle tail of pool interface.

B.2.7.1 Relocation by Electrofishing

The following methods shall be used is fish are relocated via electrofishing:

- All electrofishing will be conducted according to NOAA Fisheries Service *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (2000).
- The backpack electrofisher shall be set as follows when capturing fish: Voltage setting on the electrofisher shall not exceed 300 volts.

	Initial	Maximum
A) Voltage:	100 Volts	300 Volts
B) Duration:	500 µs (microseconds)	5 ms (milliseconds)
C) Frequency:	30 Hertz	70 Hertz

- A minimum of three passes with the electrofisher shall be utilized to ensure maximum capture probability of salmonids within the area proposed for dewatering.
- No electrofishing shall occur if water conductivity is greater than 350 microSiemens per centimeter (µS/cm) or when instream water temperatures exceed 17.8°C. Water temperatures shall be measured at the pool/riffle interface. Only direct current (DC) shall be used.
- A minimum of one assistant shall aid the fisheries biologist by netting stunned fish and other aquatic vertebrates.

B.2.7.2 Relocation by Seining

The following methods shall be used if fish are removed with seines:

- A minimum of three passes with the seine shall be utilized to ensure maximum capture probability of salmonids within the area.
- All captured fish shall be processed and released prior to each subsequent pass with the seine.
- The seine mesh shall be adequately sized to ensure fish are not gilled during capture and relocation activities.

B.2.7.3 Relocation of Salmonids

The following methods shall be used during relocation activities associated with either method of capture (electrofishing or seining):

- Fish shall not be overcrowded into buckets; allowing approximately six cubic inches per 0+ individual and more for larger/older fish.
- Every effort shall be made not to mix 0+ salmonids with larger salmonids, or other potential predators, that may consume the smaller steelhead. Have at least two containers and segregate young-of-year (0+) fish from larger age-classes. Place larger amphibians, such as Pacific giant salamanders, in container with larger fish.
- Salmonid predators, such as sculpins (*Cottus sp.*) and Pacific-giant salamanders (*Dicamptodon ensatus*) collected and relocated during electrofishing or seining activities shall not be relocated so as to concentrate them in one area. Particular emphasis shall be placed on avoiding relocation of sculpins and Pacific-giant salamanders into the steelhead and coho salmon relocation pools. To minimize predation on salmonids, these species shall be distributed throughout the wetted portion of the stream so as to concentrate them in one area.
- All captured salmonids shall be relocated, preferably upstream, of the proposed construction project and placed in suitable habitat. Captured fish shall be placed into a pool, preferably with a depth of greater than two feet with available instream cover.
- All captured salmonids will be processed and released prior to conducting a subsequent electrofishing or seining pass.

- All native captured fish will be allowed to recover from electrofishing before being returned to the stream.
- Minimize handling of salmonids. However, when handling is necessary, always wet hands or nets prior to touching fish. Handlers will not wear N,N-Diethyl-meta-Toluamide (DEET) based insect repellants.
- Temporarily hold fish in cool, shaded, aerated water in a container with a lid. Provide aeration with a battery-powered external bubbler. Protect fish from jostling and noise and do not remove fish from this container until time of release.
- Place a thermometer in holding containers and, if necessary, periodically conduct partial water changes to maintain a stable water temperature. If water temperature reaches or exceeds those allowed by CDFG and NOAA Fisheries Service, fish shall be released and rescue operations ceased.
- In areas where aquatic vertebrates are abundant, periodically cease capture, and release at predetermined locations.
- Visually identify species and estimate year-classes of fish at time of release. Count and record the number of fish captured. Avoid anesthetizing or measuring fish.
- If more three percent of the steelhead or coho salmon captured are killed or injured, the project permittee shall contact NOAA Fisheries Service's biologist Shari Anderson at 707-825-5186 or via email at shari.anderson@noaa.gov and Gayle Garman or Michelle Gilroy at CDFG (707)-445-6493. The purpose of the contact is to allow the agencies a courtesy review of activities resulting in take and to determine if additional protective measures are required. All steelhead and coho mortalities must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NOAA Fisheries Service.

B.3 Terrestrial Resources

B.3.1 Temporary Construction Impacts on Wetlands

The Dam Removal Entity (DRE) or Hydropower Licensee would be required to reduce impacts on wetlands within construction areas for the Proposed Action, the Partial Facilities Removal Alternative, the Fish Passage at Four Dams Alternative, and the Fish Passage at Two Dams Alternative. To the extent possible, wetlands within 50 feet of any ground disturbance and construction-related activities (including staging and access roads) will be clearly marked and/or fenced to avoid impacts from construction equipment and vehicles. If new temporary access roads are required, grading will be conducted such that existing hydrology will be maintained.

To reduce potential impacts on water quality in wetlands during construction, the following construction best management practices will be implemented. These measures are discussed further in Section B.1, Water Quality.

- Pollution and erosion control measures will be implemented to prevent pollution caused by construction operations and to reduce contaminated stormwater runoff.
- Oil-absorbing floating booms will be kept onsite and the contractor will respond immediately to aquatic spills during construction.
- Vehicles and equipment will be kept in good repair, without leaks of hydraulic or lubricating fluids. If such leaks or drips do occur, they will be cleaned up immediately. Equipment maintenance and/or repair will be confined to one location at each project construction site. Runoff in this area will be controlled to prevent contamination of soils and water.
- Dust control measures will be implemented, including wetting disturbed soils.
- A SWPPP will be implemented to prevent construction materials (fuels, oils, and lubricants) from spilling or otherwise entering waterways or water bodies.

B.3.2 Impacts on Special-Status Amphibian and Reptile Species and their Habitat During Construction

The DRE or Hydropower Licensee will implement actions to address the potential for mortality and disturbance of special-status amphibian and reptile species within construction areas for the Proposed Action, the Partial Facilities Removal Alternative, the Fish Passage at Four Dams Alternative, and the Fish Passage at Two Dams Alternative. Special-status amphibian and reptile species, such as western toad, northwestern pond turtle, California mountain kingsnake, and common kingsnake, could be present within construction areas and could be injured or killed.

The following measures would be required:

- Biological Resources Awareness Training. Before any ground-disturbing work (including vegetation clearing and grading) occurs in the construction area, a qualified biologist will conduct mandatory biological resources awareness training for all construction personnel and the construction foreman. This training will inform the crews about special-status species that could occur on site. The training will consist of a brief discussion of the biology and life history of the special-status species; how to identify each species, including all life stages; the habitat requirements of these species; their status; measures being taken for the protection of these species and their habitats; and actions to be taken if a species is found within the project area during construction activities. Identification cards will be issued to shift supervisors; these cards will have photos, descriptions, and actions to be taken upon sighting of special-status species during construction. Upon completion of the training, all employees will sign an acknowledgment form stating that they attended the training and understand all protection measures. An updated training will be given to new personnel and in the event that a change in special-status species occurs.
- Protocol-level Wildlife Surveys. Prior to construction, a biologist approved by the resource agencies (United State Fish and Wildlife Service (USFWS), Oregon Department of Fish and Wildlife, and/or CDFG will conduct protocol surveys to ensure no special-status animals are present within the area in which any construction activity would occur. If special-status amphibian or reptile species

are present, they will be captured and relocated to a suitable area in consultation with the resource agencies.

- Exclusion Measures for Special-Status Wildlife. Construction areas, including staging areas and access routes, will be fenced with orange plastic snow fencing to demarcate work areas. The approved biologist will confirm the location of the fenced area prior to habitat clearing, and the fencing will be maintained throughout the construction period. Additional exclusion fencing or other appropriate measures will be implemented in consultation with the resource agencies to prevent use of construction areas by special-status amphibian or reptile species during construction.

  To prevent entrapment of wildlife that do enter construction areas during activities, all excavated, steep-walled holes or trenches in excess of 2 feet deep will be inspected by a biologist or construction personnel approved by the resource agencies at the start and end of each working day. If no animals are present during the evening inspection, plywood or similar materials will be used to immediately cover the trench, or it will be provided with one or more escape ramps set at no greater than 1,000 foot intervals and constructed of earth fill or wooden planks. Trenches and pipes will be inspected for entrapped wildlife each morning prior to onset of activity. Before such holes or trenches are filled, they will be thoroughly inspected for entrapped animals. Any animals so discovered will be allowed to escape voluntarily, without harassment, before activities resume, or removed from the trench or hole by a qualified biologist approved by the resource agencies and the animals will be allowed to escape unimpeded. A biologist approved by the resource agencies will be responsible for overseeing compliance with protective measures during clearing and construction activities within designated areas throughout the construction activities.

- General Requirements for Construction Personnel include the following:
  - The contractor will clearly delineate the construction limits and prohibit any construction-related traffic outside these boundaries.
  - Construction crews will be required to maintain a 20 m.p.h. speed limit on all unpaved roads to reduce the chance of wildlife being harmed if struck by construction equipment.
  - All food-related trash items such as wrappers, cans, bottles, and food scraps generated during construction, subsequent facility operation, or permitted operations and maintenance activities of existing facilities will be disposed of in closed containers only and removed at least once a week from the site. The identified sites for trash collection will be fenced to minimize access from wildlife.
  - No deliberate feeding of wildlife will be allowed.
  - No pets will be allowed on the project site.
  - No firearms will be allowed on the project site.
  - If vehicle or equipment maintenance is necessary, it will be performed in the designated staging areas.

- Any worker who inadvertently injures or kills a federally or state listed species, bald eagle, or golden eagle, or finds one dead, injured, or entrapped will immediately report the incident to the construction foreman or biological monitor. The construction foreman or monitor will notify the resource agencies within 24 hours of the incident.

B.3.3 Impacts on Birds, Including Special-Status Bird Species, During Construction

The DRE or Hydropower Licensee will implement measures to address impacts on northern spotted owl, bald eagle, golden eagle, osprey, nesting great blue heron, willow flycatcher, and other special-status birds (as determined in consultation with the resource agencies) from disturbance during construction of the Proposed Action, the Partial Facilities Removal Alternative, the Fish Passage at Four Dams Alternative, and the Fish Passage at Two Dams Alternative.

B.3.3.1 Northern Spotted Owl

USFWS endorsed protocol-level surveys for northern spotted owl will be conducted in all areas supporting suitable habitat that may be affected by construction, including along access roads and haul routes. If, during preconstruction surveys, an active nest of northern spotted owl is identified, the DRE or Hydropower Licensee will establish a restriction buffer in consultation with the resource agencies to ensure nests are not disturbed from construction. This would include evaluation of noise levels at the nesting site. See Mitigation Measure TER-2 in Section 3.5.4.4.

B.3.3.2 Bald Eagle

Bald eagle nesting trees are known to exist within or near to construction areas, and bald eagles often use the same nests in multiple years.

Prior to construction, all necessary permits in compliance with the Bald and Golden Eagle Protection Action would be obtained. The following measures would be required to avoid or reduce impacts on bald eagle:

- Complete a two-year survey for eagle use patterns prior to construction activities. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect eagle usage.

- Prior to construction, conduct at least one focused survey for bald eagle nests within 2 miles of construction areas, including along access roads and haul routes, during the early bald eagle breeding season (January 15 through February 28). Three additional surveys would be conducted; two between March 1 and April 1, and one after April 1. Additional survey visits would be conducted to determine if eagles are nesting within 2 miles of the construction area. Before commencing construction activities during the early breeding season, at least one survey would be conducted within two weeks prior to beginning operations.

- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January 15 through August 15);
- If active nests are present within 2 miles of construction areas, a 0.5-mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active bald eagle nests are present within 0.5 miles of construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If a nest is not within line of site of the project, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced to 0.25 miles.

See Mitigation Measure TER-3 in Section 3.5.4.4.

B.3.3.3 Golden Eagle

Golden eagles are known to have historically nested in cliffs within the project area. Golden eagles are also known to nest within pine, juniper and oak trees.

The following measures would be required to avoid or reduce impacts on golden eagle:

- Complete a two-year survey for eagle use patterns prior to construction activities. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect eagle usage.
- Prior to construction, at least one protocol survey for golden eagle nests would be conducted within 5 miles of construction areas, including along access roads and haul routes, during the breeding season (January through July). Before commencing construction activities during the early breeding season, at least one focused survey would be conducted within two weeks prior to beginning operations. Additional survey visits would be conducted to determine if eagles are nesting within 2 miles of the construction area.
- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January through July).
- If active nests are present within 2 miles of construction areas, a 1-mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active golden eagle nests are present within 1 mile of construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If an active nest is not within line of site of the project, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced to 0.5 miles.

See Mitigation Measure TER-3 in Section 3.5.4.4.

B.3.3.4 Osprey

Known osprey nests are located within or near to construction areas. Some osprey nests are located on transmission line poles or other man-made platforms that would be removed during construction, or are located within areas where construction noise or human presence would cause disturbance to the birds. To avoid nesting disturbance, the nests located within or near to construction areas would be removed prior to the breeding season and replaced with nesting platforms following construction on a 1:1 basis. In addition, a search for osprey nests within 0.25 mile of construction areas, including along access roads and haul routes, would be conducted prior to beginning operations and during the breeding season, which begins in February. If active nests are present, a 0.25-mile restriction buffer would be established and delineated on maps and resource agencies would be consulted to obtain concurrence prior to conducting construction activities. See Mitigation Measure TER-2 in Section 3.5.4.4.

B.3.3.5 Willow Flycatcher

Prior to construction during the nesting season of June 1-August 31, a focused survey for willow flycatcher would be conducted within construction areas, including along access roads and haul routes. The survey would follow the established protocol described in Bombay et al (2003). If active willow flycatcher nests are detected, a 0.5-mile restriction buffer would be established and delineated on maps and resource agencies would be consulted to obtain concurrence prior to conducting construction activities. See Mitigation Measure TER-2 in Section 3.5.4.4.

B.3.3.6 Other Migratory Birds

The following measures would be required to avoid or reduce impacts on migratory birds from removal, destruction, or disturbance of active nests during construction:

- Removal or trimming of any trees or other vegetation for construction would be conducted outside of the nesting season (March 20 through August 20). This would include removal or trimming of trees along access roads and haul routes and within disposal sites.
- Where clearing, trimming, and grubbing work cannot occur outside the migratory bird nesting season, a qualified avian biologist will survey construction areas to determine if any migratory birds are present and nesting in those areas.
- For all raptors (other than eagles), inactive nests will be removed before nesting seasons begin, to the greatest extent practicable. For those nests where access is difficult, traffic cones or other deterrents in the nest platform to prevent nesting the year of construction. All deterrents will be removed as soon as possible after construction crews have passed to a point beyond the disturbance buffer for that species. See Mitigation Measure TER-2 (Section 3.5.4.4, Table 3.5-5).
- If an active nest is located, a restriction buffer in accordance with Mitigation Measure TER-2 (Section 3.5.4.4, Table 3.5-5) would be established and the

resource agencies would be consulted to obtain concurrence prior to conducting construction activities.

B.3.4 Impacts on Special-Status Plant Species During Construction

Special-status plants occurring in construction areas could be destroyed by heavy equipment. Prior to the implementation of construction activities, a botanist approved by the resource agencies would conduct protocol-level surveys within construction areas for special-status plants during the peak blooming season prior to start of construction. If any special-status plants occur within the construction areas, locations of these plants would be clearly marked and/or fenced to avoid impacts from construction equipment and vehicles where possible. If it is not possible to avoid impacts to special-status plants, Mitigation Measure TER-4 would be implemented to avoid or reduce impacts (Section 3.5.4.4).

B.3.5 Impacts Related to Invasive Plants

With implementation of the Proposed Action, the Partial Facilities Removal Alternative, the Fish Passage at Four Dams Alternative, and the Fish Passage at Two Dams Alternative, there would be potential for invasive plants to recolonize and infest disturbed areas, outcompeting native plants and adversely affecting wildlife habitat. To avoid or reduce this impact, construction vehicles and equipment would be cleaned with compressed water or air within a designated containment area to remove pathogens, invasive plant seeds, or plant parts and dispose of them in an appropriate disposal facility. The Habitat Restoration Plan (see Mitigation Measure TER-1 in Section 3.5.4.4) would include details for the installation of native plants to re-vegetate all areas disturbed during construction. Long-term maintenance and monitoring to control invasive species would be included.

B.3.6 Impacts on Plants and Wildlife Related to Vegetation Management

The structure and species composition of many forested stands have been altered through fire exclusion and past and on-going timber management. This includes mixed conifer forests, oak woodlands, and aspen. The alteration of these stands has resulted in the degradation of habitat for species associated with these vegetative communities. Additionally, many of these stands exhibit high amounts of surface and ladder fuels, increasing the potential for uncharacteristically severe wildfire. The following best management practices can reduce the effects on plants and wildlife related to vegetation management:

- Small diameter thinning of overstocked upland forests to promote development of structurally diverse stands with desired species composition and variable densities, and to reduce the risk of uncharacteristically severe wildfire.
- Prescribed burning in upland forested habitats to promote the development of understory growth and reduce the amount of small to medium diameter surface fuels.

- In oak stands, small diameter thinning (typically < 9” dbh) of dense oaks to promote the development of large structurally diverse oak trees.
- Removal of encroaching juniper (up to 15” dbh).
- Installing fencing around aspen stands to exclude livestock and allow for the
- Passive restoration of aspen trees combined with planting of native shrubs.

B.4 Public Health and Safety

B.4.1 Structure Fencing

Structures retained as part of the Partial Facilities Removal of Four Dams option would be fenced to prevent public access once decommissioning activities are completed.

B.4.2 Road Repair

Road damage as a result of heavy vehicle traffic will be repaired once decommissioning activities are completed through in-lieu payments to Siskiyou and Klamath Counties or through direct repairs by the DRE as part of the decommissioning effort.

B.5 Air Quality

B.5.1 Dust Control

Soil stabilizers or erosion control fabrics must be applied to any inactive areas of the construction site.

Water must be applied to exposed surfaces at least three times daily.

Soil must remain moist during any equipment loading and unloading activities.

Haul roads must be covered in gravel with minimal silt content.

B.6 Cultural and Historic Resources

B.6.1 Klamath Hydroelectric Project Historic Property Management Plan (HPMP)

Implement the Klamath Hydroelectric Project HPMP that is part of PacifiCorp’s relicensing application to the Federal Energy Regulatory Commission (FERC); and prepare a Programmatic Agreement that includes protocols for the identification, evaluation, and protection, and resolution of adverse effects of historic properties along the Klamath River for areas beyond the FERC boundaries of the Klamath Hydroelectric

Project. The participants in the Programmatic Agreement will include Federal agencies, the Advisory Council on Historic Preservation, California and Oregon State Historic Preservation Office, land management agencies, Indian tribes, other interested parties, and other agencies that are proposing and/or implementing management plans for the river or along it related to the Klamath Hydroelectric Settlement Agreement. The lead Federal agency for the Programmatic Agreement will be determined by agreement among the participants.

B.7 Toxic and Hazardous Materials

B.7.1 Health and Safety Plan

Prepare and implement a worker Health and Safety Plan prior to the start of construction activities. The contractor will prepare a Health and Safety Plan that should, at a minimum, identify the following:

- All contaminants that could be encountered during excavation activities
- All appropriate worker, public health, and environmental protection equipment and procedures
- Emergency response procedures
- Most direct route to a hospital
- Site Safety Officer

The plan will require documentation that all workers have reviewed and signed the plan.

B.7.2 Asbestos Handling

To mitigate the impacts regarding the abatement and disposal of asbestos and lead-based paint, prior to issuance of demolition permits, evidence shall be provided to the responsible federal agency that the demolition contract provides for a qualified asbestos and lead-based paint removal contractor/specialist to remove or otherwise abate asbestos and lead-based paint prior to or during demolition activities in accordance with federal, state, and local regulations. In addition, evidence shall be provided to the responsible federal agency that the demolition contract provides for construction contracts and/or land/building leases, provisions shall be included requiring continuous compliance with all applicable government regulations and conditions related to hazardous materials and waste management.

B.7.3 Hazardous Materials

To mitigate the potential impact of encountering hazardous materials during construction and restoration, prior to initiation of deconstruction or construction activities, the contractor will be required to prepare a Hazardous Material Management Plan for review by the DRE. The purpose of this plan is to have an established plan of action if hazardous materials (e.g., asbestos and hazardous coatings requiring abatement) are encountered during construction and to establish BMPs to reduce the potential for exposure to hazardous wastes. The plan will contain the following:

- Definition of a protocol for proper handling, transport, and disposal of hazardous materials (e.g., creosote-treated wood staves) if they are encountered during construction.
- Definition of a protocol for proper emergency procedures and handling, transport, and disposal of hazardous materials if an accidental spill occurs during construction.
- Establishment of BMPs to reduce the potential for spills of hazardous, toxic, and radioactive waste. Typical BMPs to reduce the potential for spills may include, but are not limited to:
  - Having a spill prevention and control plan with a designated supervisor to oversee and enforce proper spill prevention measures;
  - Providing spill response and prevention education for employees and subcontractors;
  - Stocking appropriate clean-up materials onsite near material storage, unloading and use areas;
  - Designating hazardous waste storage areas away from storm drains or watercourses;
  - Minimizing production or generation of hazardous materials on-site or substituting chemicals used on-site (e.g., herbicides during restoration) with less hazardous chemicals;
  - Designating areas for construction vehicle and equipment maintenance and fueling with appropriate control measures for runon and runoff; and
  - Arranging for regular hazardous waste removal to minimize onsite storage.

B.7.4 Herbicides Handling

Some restoration activities may include the handling and use of herbicides. The following best management practices measures would be implemented to protect the health and safety of herbicide handlers and prevent impacts to water quality, aquatic and terrestrial species, and special status plants, and animals near the project site(s) from herbicide treatments:

- All weed treatment activities will comply with state and Federal laws and agency manuals, handbooks, and guidelines, including United States Environmental Protection Agency (USEPA) label restrictions. Application according to all herbicide labels.
- All weeds that are pulled or cut after bud stage will be bagged and properly disposed.
- The following minimization measures are required during mixing, loading, and disposal of herbicides:
  - All mixing of herbicides will occur at least 100 feet from surface waters or well heads.

  - All hoses used to add dilution water to spray containers will be equipped with a device to prevent back-siphoning.
  - Applicators will mix only those quantities of herbicides that can be reasonably used in a day.
  - During mixing, mixers will wear a hard hat, goggles, or face shield, rubber gloves, rubber boots, and protective overalls.
  - All empty containers will be triple rinsed and disposed of by spraying near the treatment site at rates that do not exceed those on the treatment site.
  - All unused herbicides will be stored in a locked building in accordance with herbicide storage regulations.
  - All empty and rinsed herbicide containers will be punctured and either burned or disposed of in a sanitary landfill.
  - Any additional herbicide label requirements will be strictly followed during the mixing, loading, and disposal of herbicides.
- No 2,4-D ester formulations will be used.
- No carriers of adjuvants other than water will be used.
- Trained personnel would monitor weather conditions at spray sites during application. Herbicides will only be applied when no precipitation is imminent within 3 hours.
- A Pesticide Application Record will be completed daily, or as required. This will include general treatment areas, methods, and dates, and make this information available.
- Equipment will be calibrated often enough to ensure the proper amount of herbicides is applied.
- Application of any herbicides to treat weeds shall be performed by or directly supervised by a state licensed applicator.
- Mixing of herbicide will occur on a flat area more than 100 feet from streams, rivers, or lakes where accidental spills can be contained and removed before it contaminates waterbodies.
- Herbicide applicators shall be coordinated with permit holders within the project area, as appropriate.
- Adjacent landowners will be notified prior to treating weeds on public lands adjacent to private land boundaries.
- Only those quantities of herbicides necessary for the day will be transported to and from a treatment area.
- Water drafting equipment for filling spray tanks will have back siphoning prevention devices.
- Label directions and guidelines will be followed to reduce drift potential (nozzle size and pressure, additives). Equipment would be designed to deliver a median droplet diameter of 200- to 800-microns. This droplet size is large enough to avoid excessive drift while providing adequate coverage of target vegetation.
- Herbicides will only be applied when wind speeds are less than 8 miles per hour (mph).
- Spray detection cards will be used to demonstrate the adequacy of buffer zones. If cards indicate drift of herbicides is occurring into wetlands and streams, buffer zones widths and /or treatment methods would be revised.

- Non-hazardous dyes will be used as necessary to ensure uniform coverage. Sings will be posted at visible sites (campgrounds, trailheads, road intersections) to notify the public of herbicide application in the area.
- All chemicals will be applied in accordance with updated USEPA registration label requirements and restrictions, and applicable laws and policies.
- An Herbicide Emergency Spill Plan will be developed, including methods to report and clean up spills. Applicators will be required to be familiar with the plan and carry spill-containment and clean-up equipment.
- Only glyphosate (Rodeo®) will be used within 50 feet of streams/wetlands, where riparian or hydrophilic plants are present, and where surface material is obvious recent deposition of sediment of any diameter(s). Application will be limited to hand spraying and the use of wipers only.
- Only the minimum area necessary will be treated to control noxious weeds.
- A botanist shall evaluate sites for sensitive plant habitat prior to treatment and develop site-specific guidelines for herbicide application near sensitive plant populations during broadcast treatments.
- No chemical would be applied directly to sensitive plant species during spot treatments, and a 100-foot buffer would be maintained around known sensitive plant populations.
- Individuals who exhibit idiosyncratic responses such as hypersensitivity to natural and synthetic compounds will not be permitted to work on herbicide spray crews.
- Ensure all chemical storage, chemical mixing, and post-application equipment cleaning is completed in such a manner as to prevent the potential contamination of any Riparian Conservation Area (RCA), perennial or intermittent waterway, unprotected ephemeral waterway, or wetland.
- Evaluate the need to revegetate at treated sites. Use only certified noxious-weed free, native, seed mix or rootstock if revegetation is necessary for site restoration.
- When scheduling treatment activities, seasonal harvesting periods of wildlife, fish, and plants to accommodate the needs of the Tribes will be considered.
- A spill cleanup kit would be available whenever herbicides are transported or stored. All vehicles carrying herbicides shall have a standard spill kit.
- A spill contingency plan would be developed prior to all herbicide applications. Individuals involved in herbicide handling or application would be instructed on the spill contingency plan and spill control, containment, and cleanup procedures.
- Equipment used for transportation, storage, or application of chemicals shall be maintained in a leak proof condition.

B.7.4.1 Herbicide Spill Plan

Procedures for mixing, loading, and disposing of herbicides will comply with the above measures and USEPA labels and regulations. A spill prevention plan and the following procedures for mixing, loading, and disposal of herbicides will accompany all herbicide spraying operations. A reportable herbicide spill is 1 pint of concentrate of herbicide and/or 5 gallons of mixed herbicide, even if these amounts can be contained and recovered by the weed field crew. Spills that can be contained and recovered will thereafter be applied in the field according to the label requirements for the herbicide. If an herbicide spill occurs, the National Poison Control Center (1-800-222-1222) will be contacted as necessary. If there is a spill, it will be reported on approved forms. At a minimum, the following equipment and material will be available with vehicles or pack stock used to transport herbicides: (1) A shovel; (2) absorbent material or the equivalent; (3) plastic garbage bags or buckets; (4) rubber gloves and boots; (5) safety googles; (6) protective clothing; and, (7) applicable Material Safety Data Sheets.

For supplemental information needed on hazards and reactions, Chemtrek will be called (1-800-424-9300). They are an information contact only; they are not used to report a spill (Example: if a truck carrying herbicides crashes and ignites, field crews may want to know if any special hazards exist from herbicide fumes, Chemtrek is the appropriate company to call).

B.8 Traffic and Transportation

B.8.1 Roadway Signage and Dust Abatement

Install signage, implement dust abatement, and perform proper construction traffic management at each deconstruction site and along Copco, Lakeview, and Topsy Grade/Ager-Beswick Roads.

B.8.2 Construction Signage

Install construction signage onto OR66 at the entrance to J.C. Boyle Dam in accordance with the Manual of Uniform Traffic Control Devices (MUTCD) advising motorists of slow turning vehicles and overall construction traffic in the area will mitigate significant traffic safety impacts.

B.8.3 Construction Signage

If Copco Road is open and if the recreation sites are also open, install signage in accordance with MUTCD advising motorists of the presence of construction traffic in the area.

B.8.4 Roadway Signage

Install signage, in accordance with MUTCD, at sharp turns along Copco Road and OR66 advising motorists and construction vehicle drivers to slow down and be advised of potential conflicts with bicycles, pedestrians and other vehicles.

B.8.5 Road Rehabilitation

Grade to re-smooth ruts and washboard conditions created on Copco, Lakeview and Topsy Grade/Ager-Beswick Roads and at each deconstruction and construction site.

B.8.6 Pre Construction/Deconstruction Road Integrity Study

Perform a structural integrity and load carrying capacity analysis to determine the load carrying capacity of the main access roads in the area of analysis. If it is determined these main access roads are necessary for heavy equipment to use and this analysis reveals the roads do not meet local, state, or federal standards for load carrying capacity, then these roads will be upgraded to fully meet those standards.

B.8.7 Post Construction/Deconstruction Road Integrity Study

Perform a structural integrity and load carrying capacity analysis on the existing one-lane bridges at Iron Gate Dam and at J.C. Boyle Dam to aid deconstruction engineers in mitigating substantial road condition effects. If it is determined these bridges are necessary for heavy equipment to use and this analysis reveals the bridges do not meet local, state, or federal standards for load carrying capacity, then these bridges will be upgraded to fully meet those standards.

B.8.8 Impacts to Non-Surfaced Roads in Project Area

Upon the completion of restoration activities, roads within the riparian zone damaged by the permitted activity shall be weather proofed according to measures as described in *Handbook for Forest and Ranch Roads* by Weaver and Hagans (1994) of Pacific Watershed Associates and in Part X of the CDFG Restoration Manual entitled "*Upslope Assessment and Restoration Practices*." The following are some of the methods that may be applied to non-surfaced roads impacted by project activities implemented under this Program.

- Establish waterbreaks (e.g., waterbars and rolling dips) on all seasonal roads, skid trails, paths, and fire breaks by 15 October. Do not remove waterbreaks until 15 May.
- Maximum distance for waterbreaks shall not exceed the following standards; (1) for road or trail gradients less than 10%: 100 feet; (2) for road or trail gradients 11-25%: 75 feet; (3) for road or trail gradients 26-50%: 50 feet; (4) for road or trail gradients greater than 50%: 50 feet. Depending on site specific conditions more frequent intervals may be required to prevent road surface rilling and erosion.
- Locate waterbreaks to allow water to be discharged onto some form of vegetative cover, slash, rocks, or less erodible material. Do not discharge waterbreaks onto unconsolidated fill.
- Waterbreaks shall be cut diagonally a minimum of six inches into the firm roadbed, skid trail, or firebreak surface and shall have a continuous firm embankment of at least six inches in height immediately adjacent to the lower edge of the waterbreak cut.
- The maintenance period for waterbreaks and any other erosion control facilities shall occur after every major storm event for the first year after installation.

- Rolling-dips are preferred over waterbars. Waterbars shall only be used on unsurfaced roads where winter use (including use by bikes, horses, and hikers) will not occur.
- After the first year of installation, erosion control facilities shall be inspected prior to the winter period (15 October) after the first major storm event, and prior to the end of the winter period (15 May).
- Applicant will establish locations to deposit spoils well away from watercourses with the potential to delivery sediment into streams supporting, or historically supporting populations of listed salmonids. Spoils shall be contoured to disperse runoff and stabilized with mulch and (native) vegetation.
- No berms are allowed on the outside of the road edge.

B.9 General KBRA Best Management Practices

B.9.1 Limits on Area of Disturbance for Individual Projects

Stream dewatering limitations include a maximum 1000 foot length of stream that can be dewatered.

B.9.2 Upslope Disturbance (raw dirt, tree removal, canopy cover reduction)

- The disturbance footprint for the project's staging areas may not exceed 0.25 acres.
- Overstory canopy cover over a linear distance of 125 ft may not be reduced by more 15-20 percent w/in 75 ft of a watercourse or lake transition zone as measured by a spherical densiometer.
- Native trees with defects, large snags > 16 inches (in) diameter at breast height (dbh) and 20 ft high, cavities, leaning toward the stream channel, nests, late seral characteristics, or > 36 in dbh will be retained. In limited cases removal will be permitted if trees/snags occur over culvert fill. No removal will occur without a site visit and written approval from the Department of Interior or its representative.
- Downed trees (logs) > 24 in dbh and 10 ft long will also be retained on upslope sites.
- The general construction season will be from June 15 to November 1. Restoration, construction, fish relocation, and dewatering activities within any wetted and/or flowing creek channel shall only occur within this window.

B.9.3 Buffer between Projects Implemented in the Same Year

In a salmonid bearing stream, the Program will ensure maintenance of a 1500 ft downstream buffer from any other projects that increases suspended sediment concentration that are proposed for implementation that same year under the Program. In non-salmonid bearing reaches, the distance separating proposed projects that produce suspended sediments must be 500 ft apart. Variances from the buffer between projects will be considered by NOAA Fisheries Service on a project-by-project basis.

B.9.4 General Minimization Measures for All Applicable Project Types

The following minimization measures, as they apply to a particular project, shall be incorporated into the project descriptions for individual projects under the Program.

- The general construction season shall be from June 15 to November 1. Restoration, construction, fish relocation, and dewatering activities within any wetted and/or flowing creek channel shall only occur within this window. As such, all non-revegetation associated earthmoving activities shall be complete by November 1. Revegetation outside of the active channel may continue beyond October 15, if necessary. Limited earthmoving associated with preparation of the site for revegetation may occur within the October 15 - November 15 timeframe, but only as necessary for revegetation efforts. Work beyond this time frame may be authorized following consultation with and approval of NOAA Fisheries Service and CDFG, provided it could be completed prior to first flows.
- Prior to construction, each contractor shall be provided with the specific protective measures to be followed during implementation of the project. In addition, a qualified biologist shall provide the construction crew with information on the listed species and State Fully Protected Species in the project area, the protection afforded the species by the Endangered Species Act, and guidance on those specific protection measures that must be implemented as part of the project.
- All activities that are likely to result in adverse aquatic impacts, including temporary impacts, shall proceed through a sequencing of impact reduction: avoidance, reduction in size of impact, and compensation (mitigation). Mitigation may be proposed to compensate for the adverse impacts to water of the United States. Mitigation shall generally be in kind, with no net loss of waters of the U.S. on a per project basis. Mitigation work shall proceed in advance or concurrently with project construction.
- Poured concrete shall be excluded from the wetted channel for a period of 30 days after it is poured. During that time the poured concrete shall be kept moist, and runoff from the concrete shall not be allowed to enter a live stream. Commercial sealants may be applied to the poured concrete surface where difficulty in excluding water flow for a long period may occur. If sealant is used, water shall be excluded from the site until the sealant is dry and fully cured according to the manufacturers specifications.
- Herbicides may be applied to control established stands of non-native species. Herbicides must be applied to those species according to the registered label conditions. Herbicides must be applied directly to plants and may not be spread upon any water. Herbicide shall be tinted with a biodegradable dye to facilitate visual control of the spray.
- If the thalweg of the stream has been altered due to construction activities, efforts shall be undertaken to reestablish it to its original configuration. (*Note: Projects*

that may include activities such the use of willow baffles which may alter the thalweg would still be allowed under the Program.)

B.9.5 Minimization Measures for Specific Project Types

B.9.5.1 Removal of Small Dams

- Once a small dam has been removed, there will be a potential for sediment to mobilize downstream of the project site. Projects will 1) have a relatively small volume of sediment available for release, that when released by storm flows, are not likely to destroy downstream habitat or 2) are designed to remove sediment trapped by the dam down to the elevation of the target thalweg including design channel and floodplain dimensions. This can be accomplished by estimating the natural thalweg using an adequate longitudinal profile (see CDFG Manual Part XII Fish Passage Design and Implementation) and designing a natural shaped channel that provides the same hydraulic conditions and habitat for listed fish that is provided by the natural channel and has the capacity to carry flows up to the 2-year flood.
- All construction will take place out of the wetted channel either by implementing the project from the bank and out of the channel or by constructing coffer dams, removing aquatic species located within the project reach, and dewatering the channel.
- No more than 250 linear feet (125 feet on each side of the channel) of riparian vegetation will be removed during this process. All disturbed areas will be re-vegetated with native grasses, trees, and shrubs.
- All dewatering efforts associated with small dam removal will abide by the minimization measures for stream dewatering.
- Data Requirements and Analysis to be Provided:
  - A longitudinal profile of the stream channel thalweg for at least 20 channel widths upstream and downstream of the structure and long enough to establish the natural channel grade, whichever is farther, shall be used to determine the potential for channel degradation (as described in the CDFG Manual).
  - A minimum of five cross-sections; one downstream of the structure, three through the reservoir area upstream of the structure, and one upstream of the reservoir area outside of the influence of the structure - to characterize the channel morphology and quantify the stored sediment.
  - Sediment characterization within the reservoir and within a reference reach of a similar channel to determine the proportion of coarse sediment (>2mm) in the reservoir area and target sediment composition.
  - A survey of any downstream spawning areas that may be affected by sediment released by removal of the water control structure.

Projects will be deemed ineligible for the program if:

1) Sediments stored behind dam have a reasonable potential to contain environmental contaminants (dioxins, chlorinated pesticides, polychlorinated biphenyls (PCB’s),

or mercury) beyond the freshwater probable effect levels (PELs) summarized in the NOAA Screening Quick Reference Table guidelines found at http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf, or

2) The risk of significant loss or degradation of downstream spawning or rearing areas by sediment deposition is considered to be such that the project requires more detailed analysis. Sites should be considered to have a reasonable potential to contain contaminants of concern if they are downstream of historical contamination sources such as lumber or paper mills, industrial sites, or intensive agricultural production going back several decades (i.e. since chlorinated pesticides were legal to purchase and use).

In these cases, preliminary sediment sampling is advisable.

B.9.5.2 Creation of Off-Channel/Side Channel Habitat

To reduce the impacts of turbidity the same measures used for instream habitat improvement projects will be required including:

- Any equipment work within the stream channel shall be performed in isolation from the flowing stream. If there is any flow when the work is done, the grantee shall construct coffer dams upstream and downstream of the excavation site and divert all flow from upstream of the upstream dam to downstream of the downstream dam. The coffer dams may be constructed from many different materials and methods to meet the objective, for example clean river gravel or sand bags, and may be sealed with sheet plastic. Foreign materials such as sand bags and any sheet plastic shall be removed from the stream upon project completion. In some cases, clean river gravel may be left in the stream, but the coffer dams must be breached to return the stream flow to its natural channel.
- If it is necessary to divert flow around the work site, either by pump or by gravity flow, the suction end of the intake pipe shall be fitted with fish screens meeting CDFG and NOAA Fisheries Service criteria to prevent entrainment or impingement of small fish. Any turbid water pumped from the work site itself to maintain it in a dewatered state shall be disposed of in an upland location where it will not drain directly into any stream channel, or treated to filter suspended materials before flowing back into the stream.

Projects requiring extensive analysis may not be eligible for programmatic coverage, and would need to undergo separate consultation.

B.9.5.3 Developing Alternative Stockwater Supply

- Only projects with existing diversions compliant with water laws will be considered. In addition, storage reservoirs will not be greater than 10 acre-feet in size. Flow measuring device installation and maintenance may be required for purposes of accurately measuring and managing pumping rate or bypass conditions set forth in this document or in the water right/use permit

- All pump intakes will be properly screened in accordance with NOAA Fisheries Service Southwest Region Fish Screening Criteria for Salmonids, as discussed and referenced in Appendix S of the Restoration Manual.
- Stockwater ponds and wells will be located outside of the riparian zone and are not likely to cause standing of juvenile salmonids during flood events.

B.9.5.4 Tailwater Collection Ponds

- Tailwater collection ponds that do not incorporate egress channels back to the creek will be located at least 100 feet from the active channel and are not likely to cause stranding of juvenile salmonids during flood events.

Water conservation projects that include water storage tanks and a Forbearance Agreement for the purpose of storing winter and early spring water for summer and fall use, require registration of water use pursuant to the Water Code §1228.3, and require consultation with CDFG and compliance. Diversions to fill storage facilities during the winter and spring months shall be made pursuant to a Small Domestic Use Appropriation (SDU) filed with the State Water Resources Control Board (SWRCB). CDFG and NOAA will review the appropriation of water to ensure fish and wildlife resources are protected.

B.9.5.5 Piping Ditches

- Only water conservation piping projects that result in a decrease in the diversion rate with a permitted instream dedication of the water saved are covered by this permit.
- Landowners will enter an agreement with NOAA or the United States Army Corps of Engineers (USACE) stating that they will maintain the pipe for 10 years.

B.9.5.6 Fish Screens

- All flows will be diverted around work areas as described below in *Requirements for Fish Relocation and Dewatering Activities*.
- Fish removal may be required at project sites and BMPs will be implemented as described below in *Requirements for Fish Relocation and Dewatering Activities*.
- Riparian disturbance will be minimized as described below in *Measures to Minimize Loss or Disturbance of Riparian Vegetation*.

B.9.5.7 Headgates, Water Measuring Devices, and Re-profiling Ditches

- The applicant must provide instream and ditch/pump hydraulic calculations showing there is sufficient head to divert maximum diversion flow and bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, headgates, etc.
- Measuring devices must be approved by the Department of Water Resources (DWR) for watersheds with DWR water master service. Otherwise, measuring devices must conform to the *2001 Bureau of Reclamation Water Measurement Manual* (Bureau of Reclamation [Reclamation] 2001) which can be found at (http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/index.htm).

- Design drawings must show structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views along with important component details.
- All flows will be diverted around work areas as described in Section II B. *Requirements for Fish Relocation and Dewatering Activities*.
- Fish removal may be required at project sites and BMPs are described in Section II B. Requirements for Fish Relocation and Dewatering Activities.
- Riparian disturbance will be minimized as described in Section II E. *Measures to Minimize Loss or Disturbance of Riparian Vegetation*.

B.9.5.8 Water Conservation Projects

- All water conservation projects included under this programmatic will require diverters to verify compliance with water rights – as conditioned by a small domestic use or livestock stockpond registration, appropriative water right, or a statement of riparian water use registered with the State Water Resource Control Board and reviewed for compliance with California Fish and Game Code by CDFG (which may require a Lake or Streambed Alteration Agreement and possibly, a California Environmental Quality Act (CEQA) analysis).
- Restrictions on water diversions from a stream or from hydrologically connected sources (such as springs or groundwater that would contribute to streamflow) are often site specific. Permitted diversions may have limits on or requirements for:
  - Season of diversion
  - Rates of diversion
  - Possible time-of-day restrictions (avoiding daytime peak in forest evapotranspiration and water temperature, or coordination with other users)
  - Fish screen requirements for direct diversions
  - Requirements for water storage during high flow periods for use in low flow periods
  - Flow or diversion monitoring and reporting.
- Restrictions are intended to protect instream flows beneficial to fish rearing, spawning, and movement as well as providing habitat native amphibians and other aquatic species.

B.9.6 Engineering Requirements

More complex project types covered by the Program will require a higher level of oversight (engineering review, etc.) and review by either NOAA Fisheries Service regulatory agency staff, agency engineers, or CDFG engineers. These project types will include:

- Fish passage at stream crossings
- Permanent removal of flashboard dam abutments and sills.
- Small dam removal
- Creation and/or connection of off channel habitat features

Specific requirements associated with these more complex project types include the following:

- For stream crossing and small dam projects, if the stream at the project location was **not** passable to or was not utilized by all life stages of all covered salmonids prior to the existence of the road crossing, the project shall pass the life stages and covered salmonid species that historically did pass there. Retrofit culverts shall meet the fish passage criteria for the passage needs of the listed species and life stages historically passing through the site prior to the existence of the road crossing according to NOAA Fisheries Service and CDFG stream crossing criteria.
- All designs for dam removal, off channel habitat features, and fish passage projects must be reviewed and authorized by NOAA Fisheries Service (or CDFG) engineers, ensuring the requirements have been met prior to commencement of work. Off channel habitat projects that reduce the potential for stranding using water control structures will be encouraged, but uncertainties in future stream flows and drought conditions cannot be predicted and may result in fish stranding in certain flow conditions.

B.9.7 Prohibited Activities

Projects that include any of the following elements would not be authorized under this Program and would require separate consultation with NOAA Fisheries Service:

- Use of gabion baskets
- Use of cylindrical riprap (aqualogs)
- Chemically-treated timbers used for grade or channel stabilization structures, bulkheads or other instream structures
- Activity that substantially disrupts the movement of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the action area
- Projects that would completely eliminate a riffle/pool complex (*note: there may be some instances where a riffle/pool complex is affected/modified by a restoration project [i.e. a culvert removal that affects an existing pool]. These types of projects would be allowed under the Program*).

B.10 References

Bureau of Reclamation (Reclamation). 2001. Water Measurement Manual. Accessed on August 9, 2011. Available at: http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/index.htm.

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National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries Service). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act. Accessed August 11, 2011. Available at: http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf

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Appendix C
Water Quality Supporting Technical Information

C.1 Water Temperature

C.1.1 Upper Klamath Basin

C.1.1.1 Wood, Williamson, and Sprague Rivers

The Williamson River, the Sprague River and their major tributaries are listed as impaired under Section 303(d) of the Clean Water Act (CWA) for water temperature based upon the 18ºC (64.4ºF) criteria for salmon and trout rearing (Oregon Department of Environmental Quality [ODEQ] 1998; see Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) Section 3.2, Table 3.2-8). For waters supporting redband cutthroat trout, the temperature criterion is a 7-day average maximum temperature of 20ºC (68ºF) (see Section 3.2, Table 3.2-8).

Mainstem water temperature in the Williamson and Sprague rivers have maximum values (21ºC [70ºF]) during May–October (ODEQ 2002, Attachment 1). Exposure to solar radiation during summer and early fall months heats surface water rapidly in headwater meadows of the Williamson River (David Evans and Associates [DEA] 2005). Heat energy is dissipated through turbulence occurring downstream of small impoundments and meadows on these rivers, and localized cooling from groundwater springs has been indicated along the mainstem Williamson and Sprague rivers. Spring Creek, Larkin Springs, Wickiup Spring, Williamson River Spring and Kamkaun Spring are examples of large groundwater sources that appear to have a significant cooling effect on surface waters in these tributaries to Upper Klamath Lake (ODEQ 2002, Attachment 1). Seasonal irrigation withdrawals and agricultural return flows increase mainstem stream temperatures during summer time, depending upon relative flow volume and air temperatures. Widespread removal of riparian vegetation and alterations to channel morphology also increase summer water temperatures in the Williamson and Sprague rivers. While the Upper Klamath Lake Total Maximum Daily Load (TMDL) and water quality management plan were completed in 2002, the Williamson and Sprague rivers will retain their water quality limited status until they achieve water quality standards.

The Wood River is listed as attaining cold water fish rearing temperature (18ºC [64.4 F]) from River Mile (RM) 0–17.9 (ODEQ 2002, Attachment 1). Wood River originates from a group of springs near Fort Klamath and stream flow is mostly groundwater-derived.

Campbell et al. (1993) report year-round headwater stream temperatures of 4.7–7.4ºC (40.5–45ºF) and water entering Agency Lake at 2.3–16.8ºC (36–62ºF).

C.1.1.2 Upper Klamath Lake

Water temperatures in Upper Klamath Lake regularly exceed 20ºC (68ºF) during July and August based on data collected since 1990 (Kann 2010). The mean depth of the lake is relatively shallow, at 8 feet when the lake level is at mean summer elevation (1,262.3 m [4,141.3 ft]; Gearhart et al. 1995), increasing the effect of solar radiation on lake temperatures beyond that of deeper lakes. Upper Klamath Lake undergoes periods of intermittent, weak stratification (Kann and Walker 1999), which has implications for dissolved oxygen and pH (Wood et al. 2006). As described above, water inputs from the Williamson River exceed 20ºC (68ºF) during the summer months (U.S. Geologic Survey [USGS] Data Grapher 2010). Groundwater discharges providing cooler water directly to the lake appear to have little effect on overall water temperature, with the exception of springs in or near Pelican Bay on the northwest side of the lake.

C.1.1.3 Link River Dam to Klamath River upstream of J.C. Boyle Reservoir

The Upper Klamath River is listed as impaired under Section 303(d) of the CWA for summertime water temperature (see Section 3.2, Table 3.2-8). Weekly measurements in 2007 in the Link River and upper Keno Impoundment reveal maximum temperatures of 23ºC (73.4ºF) in mid-to-late summer (Appendix B in Sullivan et al. 2008). Keno Impoundment exhibits a weak, intermittent stratification during the summer months, with maximum water temperatures exceeding 25ºC (77ºF) (Deas and Vaughn 2006). Recorded average monthly temperatures (2001–2004) in Keno Impoundment are 22.4ºC (72.3ºF) in July, 20.8ºC (69.4ºF) in August and 18.0ºC (64.4ºF) in September (Federal Energy Regulatory Commission [FERC] 2007). Average monthly temperatures reported by PacifiCorp downstream of Keno Dam are 23.2ºC (73.8ºF), 21.1ºC (70.0ºF), and 16.9ºC (62.4ºF) during July, August, and September (2001–2004), respectively (FERC 2007), exceeding Oregon water quality objectives for core coldwater habitat (16°C [60.8°F]) (see Section 3.2, Table 3.2-3). Similarly, during 2009, summer water temperatures downstream of Keno Dam were generally greater than 16°C (60.8°F) from June–September, with peak temperatures exceeding 26°C (78.8°F) in late-July (Watercourse Engineering, Inc. 2011).

C.1.1.4 Hydroelectric Reach

The Hydroelectric Reach spans the Oregon–California state line; both states include this reach on their Section 303(d) lists of impaired waters for water temperature (see Section 3.2, Table 3.2-8). During summer months, maximum weekly maximum temperatures (MWMTs) in the Hydroelectric Reach regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support (North Coast Regional Water Quality Control Board [NCRWQCB] 2010, Kirk et al. 2010).

In general, water temperatures in this reach follow a seasonal pattern, with average monthly water temperatures from March through November ranging from just over 5°C (41ºF) in November to more than 22°C (71.6ºF) during June through August (FERC 2007). Winter water temperatures throughout the reach are largely driven by the temperature of river inflows (Deas and Orlob 1999). In the summer, the relatively shallow J.C. Boyle Reservoir (like the upstream Keno Impoundment) does not exhibit long-term thermal stratification, with a typical vertical temperature difference of less than 2°C (3.6ºF) in the water column (FERC 2007; Raymond 2008, 2009, 2010). Downstream of J.C. Boyle Dam, at approximately RM 224.7, water from cool groundwater springs at a relatively constant 11 to 12ºC (51.8 to 53.6ºF) mixes with river water that can exceed 25ºC (77ºF) in July and August (Kirk et al. 2010). When combined with peaking flows from the upstream J.C. Boyle Powerhouse, the groundwater springs create a unique summertime temperature signal on the Klamath River downstream of J.C. Boyle Dam; non-peaking flows are dominated by the cooler spring water while peaking flows are dominated by warmer water from reservoir discharges (PacifiCorp 2006, Kirk et al. 2010).

Within and downstream of Copco 1 Reservoir, spring, summer and fall temperatures in the Hydroelectric Reach are heavily influenced by the large thermal mass of the two deepest reservoirs, Copco 1 and Iron Gate Reservoirs, and their seasonal stratification patterns. Spring temperatures are generally cooler than would be expected under natural conditions, and summer and fall temperatures are generally warmer (PacifiCorp 2004a, NCRWQCB 2010). Both Iron Gate and Copco 1 Reservoirs thermally stratify beginning in April/May and do not mix again until October/November (Table C-1). The onset of spring/summer stratification and the timing of fall turnover in Iron Gate and Copco 1 Reservoirs are driven by meteorological conditions (Deas and Orlob 1999).

Table C-1. General Reservoir Turnover Dates for Copco 1 and Iron Gate Reservoirs (2007–2009).

Year	Thermally Stable Hypolimnion Establishment Date		Approximate Reservoir Turnover Date		Source
	Copco	Iron Gate	Copco	Iron Gate	
2007	By June 6	By June 6	Before October 23	Before November 28	Raymond 2008
2008	By April 30	By April 30	Before October 22	Before November 19	Raymond 2009
2009	By May 24	By May 24	Before October 13	Before November 17	Raymond 2010

Powerhouse withdrawals for Copco 1 and Iron Gate Dams are primarily from the epilimnion (surface waters). In Copco 1 Reservoir, powerhouse withdrawal is from approximately 6 m (20 ft) below the water surface when the reservoir is full and in Iron Gate Reservoir powerhouse withdrawal is from approximately 12 m (39 ft) below the water surface (National Research Council 2003). Occasionally, withdrawals extend into the hypolimnion; for example, in Iron Gate Reservoir, the withdrawal envelope has been estimated to extend down to approximately 18 m (60 ft) in depth (Deas and Orlob 1999).

Additionally, a small withdrawal (about 50 cfs) for the Iron Gate Hatchery occurs from the hypolimnion at Iron Gate Reservoir. In general, however, temperature in waters discharged from Copco 1 and Iron Gate Reservoirs reflect the warmer temperatures of surface water (National Research Council 2003). Stratification of the reservoirs also prevents mixing of waters within the water column and affects dissolved oxygen, nutrient concentration (and speciation), and pH in the Hydroelectric Reach and the Klamath River just downstream of Iron Gate Dam (Section C.1.2).

C.1.2 Lower Klamath Basin

C.1.2.1 Iron Gate Dam to Salmon River

The middle portion of the Klamath River, including the reach between Iron Gate Dam and the Salmon River, is listed as impaired under Section 303(d) of the CWA for water temperatures (see Section 3.2, Table 3.2-3). Water temperature in the Lower Klamath Basin varies seasonally, with mean monthly temperatures in the river downstream of Iron Gate Dam ranging from 3 to 6°C (37–43°F) in January to 20–22.5°C (68–72.5°F) in July and August (Bartholow 2005, Karuk Tribe of California 2009, Watercourse Engineering, Inc. 2011). Based upon annual water temperature monitoring conducted by the Karuk Tribe since 2000, water temperatures peak during the summer when air temperatures increase and flows decrease in the Klamath Basin (Figure C-1; Karuk Tribe of California 2002, 2003, 2007, 2009, 2010). Daily average summer water temperatures documented immediately downstream of Iron Gate Dam are generally cooler and less variable than those documented farther downstream in the Klamath River; daily average temperatures between June and September are approximately 1–4°C (1.8–7.2°F) higher near Seiad Valley and just downstream of the Salmon River confluence (i.e., at Orleans) than those just downstream of Iron Gate Dam (Figure C-2; Karuk Tribe of California 2009, 2010).

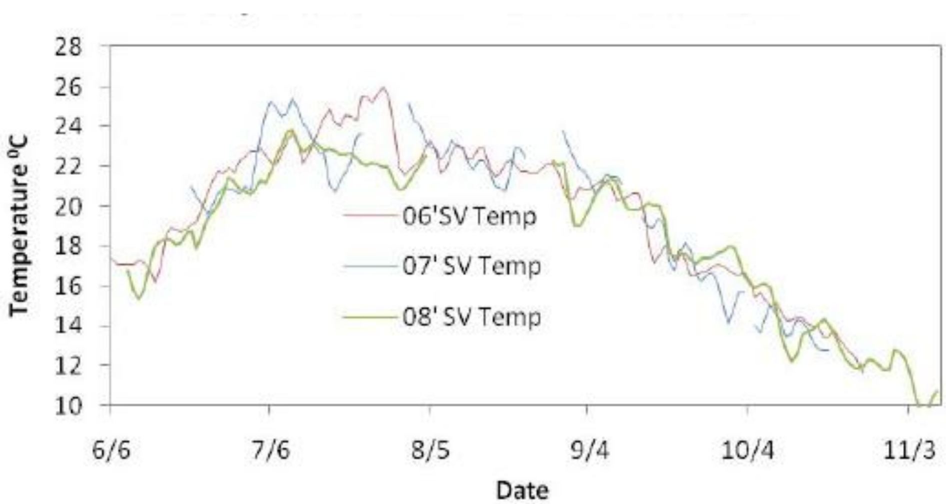


Figure C-1. Daily Average Water Temperature in the Klamath River near Seiad Valley (RM 129.4) June through November 2006, 2007, and 2008. Source: Karuk Tribe of California 2009.

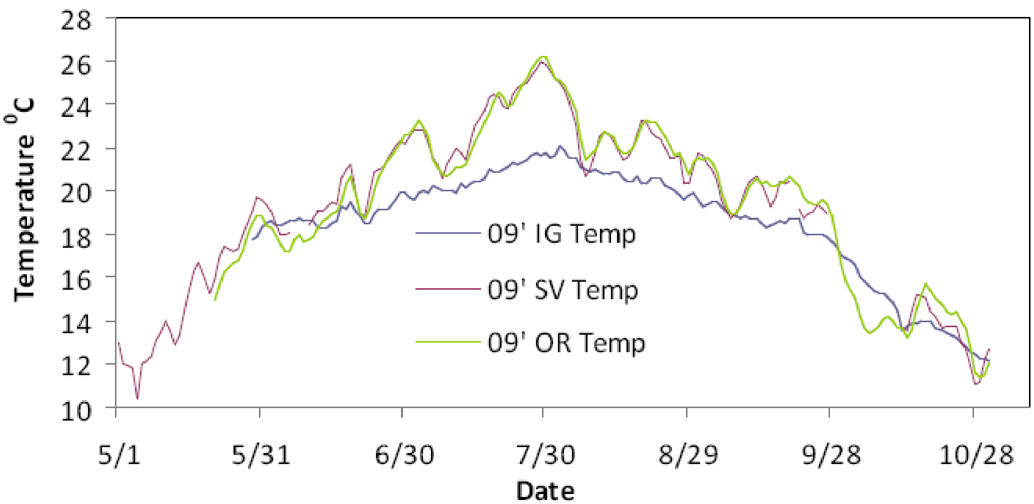


Figure C-2. Daily Average Water Temperature in the Klamath River Downstream of Iron Gate Dam (≈RM 189), near Seiad Valley (RM 129.4) and at Orleans (RM 59) during May through October 2009. Source: Karuk Tribe of California 2010.

With respect to the longer term water temperature record (i.e., prior to 2000), Bartholow (2005) presents evidence that water temperatures in the lower Klamath River have been increasing since before 1950. Bartholow (2005) indicates that the observed multi-decade trend of increasing water temperatures in the lower river is related to the cyclic Pacific Decadal Oscillation and is consistent with a measured average basinwide air temperature increase of 0.33°C/decade (0.59°F/decade). Bartholow (2005) estimates that the season of high temperatures that are potentially stressful to salmonids has lengthened by about 1 month in the Klamath River since the early 1960s, and the average length of the lower river exhibiting a summer water temperatures less than 15°C (59°F) has declined by about 8.2 km/decade (5.1 mi/decade). Potential climate change effects on water temperature are discussed in more detail as part of the effects determination for the No Action/No Project Alternative (see Section 3.2.4.3 – No Action/No Project Alternative – Water Temperature).

C.1.2.2 Salmon River to Estuary

The lower Klamath River between the Salmon River and the Klamath Estuary is listed as impaired under Section 303(d) of the CWA for water temperature (see Section 3.2, Table 3.2-3). Water temperature monitoring by the Karuk Tribe includes data from Orleans (RM 59), which is just downstream of the Salmon River confluence with the mainstem. Daily average water temperature at Orleans was 10.5–26°C (50.9–78.8ºF) from June through November 2006–2008, with the warmest temperatures generally occurring during July (Figure C-3; Karuk Tribe of California 2009). In the mainstem river between the Klamath River's confluence with the Trinity River and the Klamath Estuary, the Yurok Tribe, through the Yurok Tribe Environmental Program (YTEP) has conducted annual water temperature monitoring since 2002 (YTEP 2004). Peak temperatures generally occur in mid- to late-July, with the highest daily maximum temperatures recorded at the most upstream locations and a small (0.5°C [0.9°F]) cooling effect detected from the contribution of the Trinity River to the mainstem Klamath River (Sinnott 2010). During May through November 2009, water temperatures ranged from approximately 11.1°C (52.0°F) in October to 26.8°C (80.2°F) in July (Sinnott 2010). Daily maximum summer water temperatures were greater than 26°C (78.8°F) just upstream of the confluence with the Trinity River (Weitchpec [RM 43.5]), decreasing to 24.5°C (76.1°F) near Turwar Creek (RM 5.8) (Figure C-4, YTEP 2005, Sinnott 2010). These summer temperatures exceed optimal growth thresholds as well as critical thermal maxima for coho, Chinook salmon, and steelhead (Brett 1952, Armour 1991, Stein et al. 1972, McGeer et al. 1991). Historically, summer water temperature maxima in the lower Klamath River have been greater than in other coastal rivers to the north and south. For example, Blakey (1966, as cited in Bartholow 2005), reports water temperatures in the Klamath River downstream of the Trinity River confluence (RM 42.5) reaching 26.6°C (79.9°F) for up to 10 days per year, in contrast to proximal coastal rivers that never reach this temperature

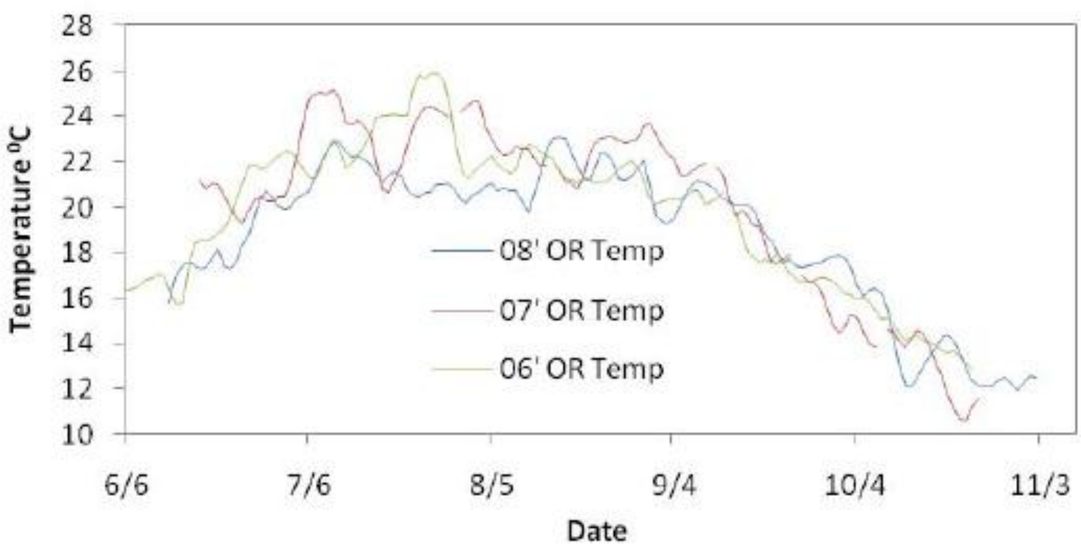


Figure C-3. Daily Average Water Temperature in the Klamath River at Orleans (RM 59) June through November 2006, 2007, and 2008. Source: Karuk Tribe of California 2009.

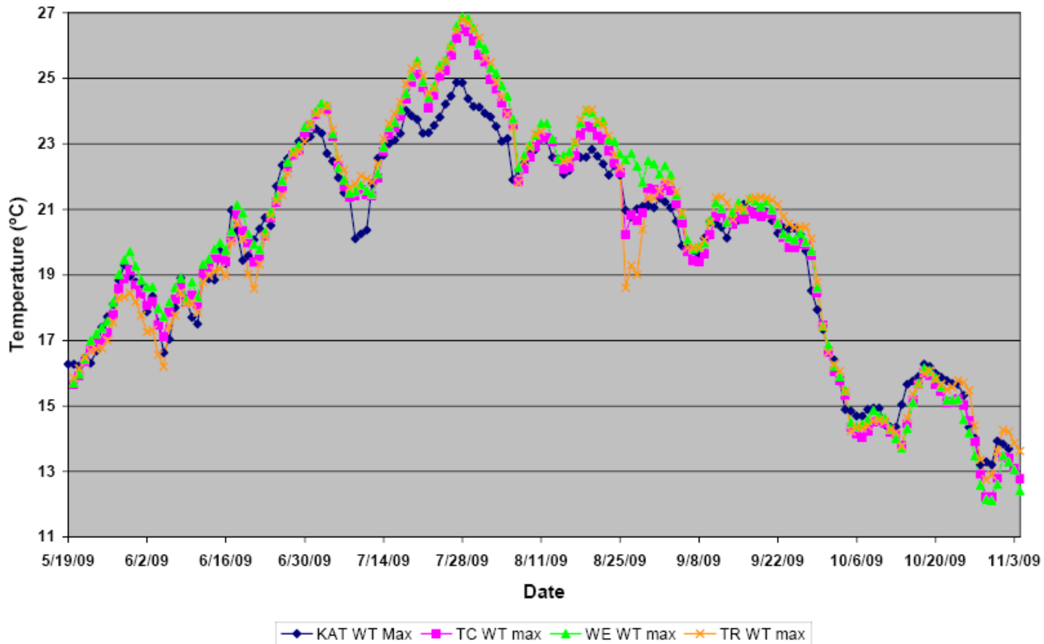


Figure C-4. Daily Maximum Water Temperatures in the Klamath River at Weitchpec (RM 43.5 [WE]), Upstream of Tully Creek (RM 38.5 [TC]), and Upstream of Turwar Boat Ramp (RM 8 [KAT]), as well as in the Trinity River (RM 40) near the Confluence with the Klamath River (RM 0.5 [TR]) May through November 2009. Source: Sinnott 2010.

C.1.2.3 Klamath Estuary

Hydrodynamics and water quality within the estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, vertical water column stratification (thermal and/or chemical), and location of the estuary mouth, the latter changing due to periodic sand bar movement. The lower Klamath River, including the estuary, is listed as impaired under Section 303(d) of the CWA for water temperature (see Section 3.2, Table 3.2-3). Water temperature has been monitored in the Klamath Estuary by California Department of Fish and Game (Wallace 1998) and most recently by the Yurok Tribe Fisheries Program (Hiner 2006) and the YTEP (2005), with support from the NCRWQCB. Water temperatures in the estuary from December through April are roughly 5–12°C (41–54°F) (Hiner 2006). In summer and fall months, warmer air temperatures and lower flows result in increased water temperatures. Under low-flow summertime conditions, water temperatures in the estuary have been observed at 20–24°C (68–75.2°F) (Wallace 1998) or greater than 24°C (75.2°F) (Hiner 2006). During June–September 2009, water temperatures were 18.7–20.7°C (65.7–69.3°F) (Watercourse Engineering, Inc. 2011). These levels exceed optimal growth thresholds for salmonids, as cited in the previous section.

Estuarine water temperature is linked to upstream hydrology and periods of mouth closure because when the estuary mouth is open, denser salt water from the ocean sinks below the lighter fresh river water, resulting in chemical stratification and a "salt wedge" that moves up and down the estuary with the daily tides (Horne and Goldman 1994, Wallace 1998, Hiner 2006). The salt wedge is also thermally stratified with cooler, high salinity ocean waters remaining near the estuary bottom, and warmer, low salinity river water near the surface. Upstream hydrology can affect the location of the salt water wedge and thus affect thermal structure in the estuary. For example, during pulse flows released from the Lewiston Dam on the Trinity River in August 2004, the upstream extent of the salt wedge moved downstream approximately one mile (YTEP 2005). In the Klamath Estuary, mouth closure has been reported to reduce the size of the salt water wedge, decrease overall salinity, and subsequently increase water temperatures in the estuary (Hiner 2006). Mouth closure, caused by formation of a sand berm across the mouth of the estuary, is a function of off-shore and alongshore wave power and sediment supply, freshwater inflows, the tidal prism, and morphological characteristics of the inlet (Escoffier 1940, Brunn 1966, O'Brien 1971, Barnes 1980). The historical frequency and duration of mouth closure in the Klamath Estuary has not been documented, although it is expected to occur during low-flow periods (June–October).

C.2 Suspended Sediments

For the purposes of the Klamath Facilities Removal EIS/EIR, suspended sediments refer to settleable suspended material in the water column. Bed materials, such as gravels and larger substrates, are discussed in Section 3.3.3.2 Aquatic Resources – Existing Conditions/Affected Environment – Physical Habitat Descriptions. Two types of suspended material are considered for the EIS/EIR analysis: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each within the Upper and Lower Klamath Basins.

Often, suspended materials in the water column are quantified by measuring the concentration of total suspended solids (TSS). Turbidity, an optical property referring to the amount of light scattered or absorbed by a fluid, is another common way to quantify suspended materials and is measured in nephelometric turbidity units (NTUs). The exact relationship between turbidity and suspended sediment is dependent on the parent geology and must be determined for each watershed (Montgomery 1985, MacDonald et al. 1991). Turbidity and TSS affect organisms directly (e.g., interfering with vision) or indirectly by changing water temperature and Dissolved Oxygen (DO), and are often associated with the sorption of contaminants from the water column (e.g., polar organics and cationic metal forms). Municipal and domestic water supply beneficial uses can also be adversely affected by changes in suspended sediment concentrations and turbidity in streams.

For the Klamath River, coincident turbidity data is occasionally presented along with TSS data. However, as the dataset is not consistent in space or time, turbidity levels are not used to support significance determinations (see Section 3.2.4.2 – Thresholds of

Significance for Narrative Standards or Water Quality Objectives – Suspended Sediments) and are not analyzed in detail in this EIS/EIR.

C.2.1 Upper Klamath Basin

C.2.1.1 Wood, Williamson, and Sprague Rivers

Recently collected USGS data (2008–2010) for TSS at the Williamson River near Chiloquin indicate a range of 3–63 milligrams per liter (mg/L) with peak values occurring in February and March of 2009 (Figure C-5). Coincident turbidity data collected roughly monthly from March 2008 to July 2009 at this same location range from 1.6 to 35 formazin nephelometric units with similar peaks during late winter/early spring. Causes of fine sediment delivery to the upper Williamson River that may increase suspended sediment and turbidity include stream bank erosion from agricultural lands, lack of interception from riparian vegetation, timber harvest, and road construction and maintenance (DEA 2005, ODEQ 2002). Road density in the upper Williamson River subbasin is approximately 3.45 mi/mi2, with 6.4 percent of total road miles found within 200 feet of a stream channel (DEA 2005). For the Williamson River watershed as a whole, the number of stream crossings per mile of road (road/stream crossing density) is reported as 0.4 (Bureau of Land Management 2005, 2006; as cited in Rabe and Calonje 2009). Most of the roads in the Winema National Forest, in the eastern portion of the Williamson River subbasin, are dirt gravel (unpaved) (Gearhart et al. 1995) and produce fine sediment that can be delivered directly to streams (DEA 2005). Based on a watershed analysis of the Deep, Sand and Aspen Creek tributaries to the Williamson River, estimates of total road sediment yield are 5 to 20 times greater than background rates, with the greatest yield originating in the Sand Creek subbasin (Weyerhaeuser Company 1996, as cited in DEA 2005).

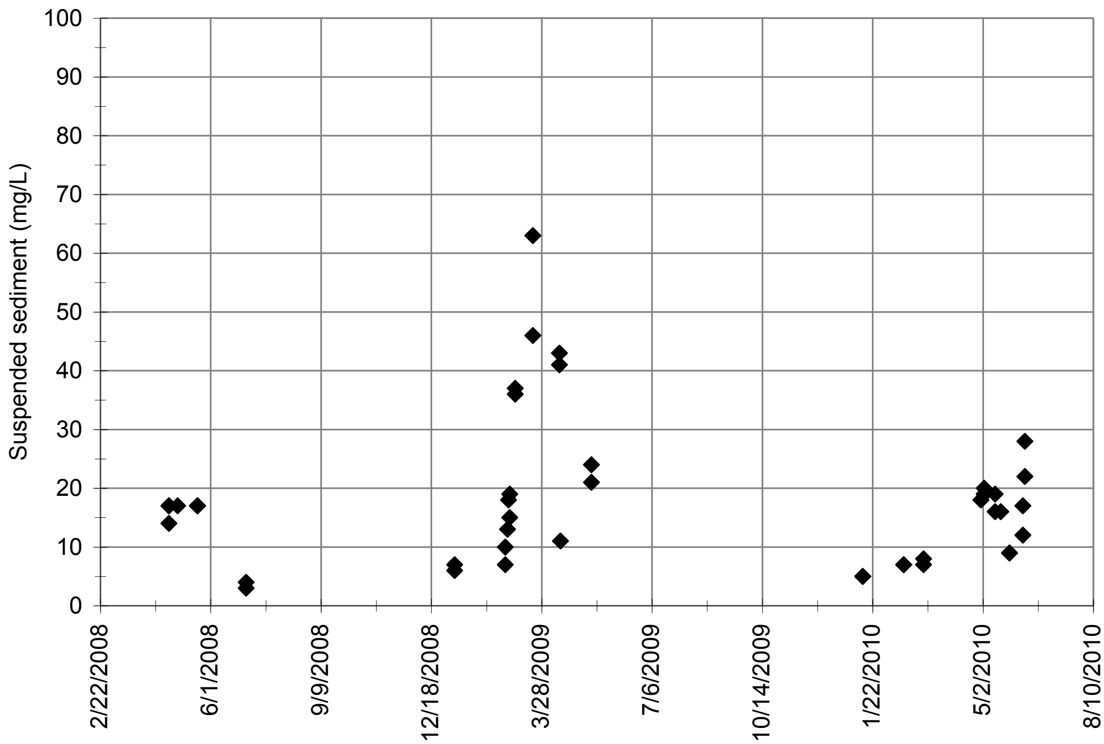


Figure C-5. Suspended Sediment (mg/L) Grab Samples for USGS Williamson River downstream of Sprague River near Chiloquin (USGS Gage No. 11502500) 2008–2010. Source: USGS 2011 (http://waterdata.usgs.gov/nwis)

Recently collected USGS data (2008–2010) for TSS at the Sprague River at Chiloquin range 4–88 mg/L with peak values generally occurring in February and March (Figure C-6). Coincident turbidity data collected roughly monthly from March 2008 to July 2009 at this same location were 2–53 formazin nephelometric units, with similar peaks during late winter/early spring. The Sprague River has been identified as a primary source of sediment to Upper Klamath Lake, based on analyses conducted to determine associated phosphorus loading to the lake (Gearheart et al. 1995). Relatively high and variable rates of runoff and erosion in the Sprague River drainage, as compared to the Williamson River drainage, have been identified as the source of bound phosphorus generated during seasonal runoff events and delivered to Upper Klamath Lake (ODEQ 2002, Connelly and Lyons 2007). The high sediment delivery rates have been identified as a factor affecting water temperatures in the upper basin and have altered relationships between depth and width of stream channels (Gearheart et al. 1995, ODEQ 2002). The sources of the sediment inputs within the Sprague River drainage include agriculture, livestock grazing and forestry activities, and road-related erosion (ODEQ 2002, Connelly and Lyons 2007, Rabe and Calonje 2009).

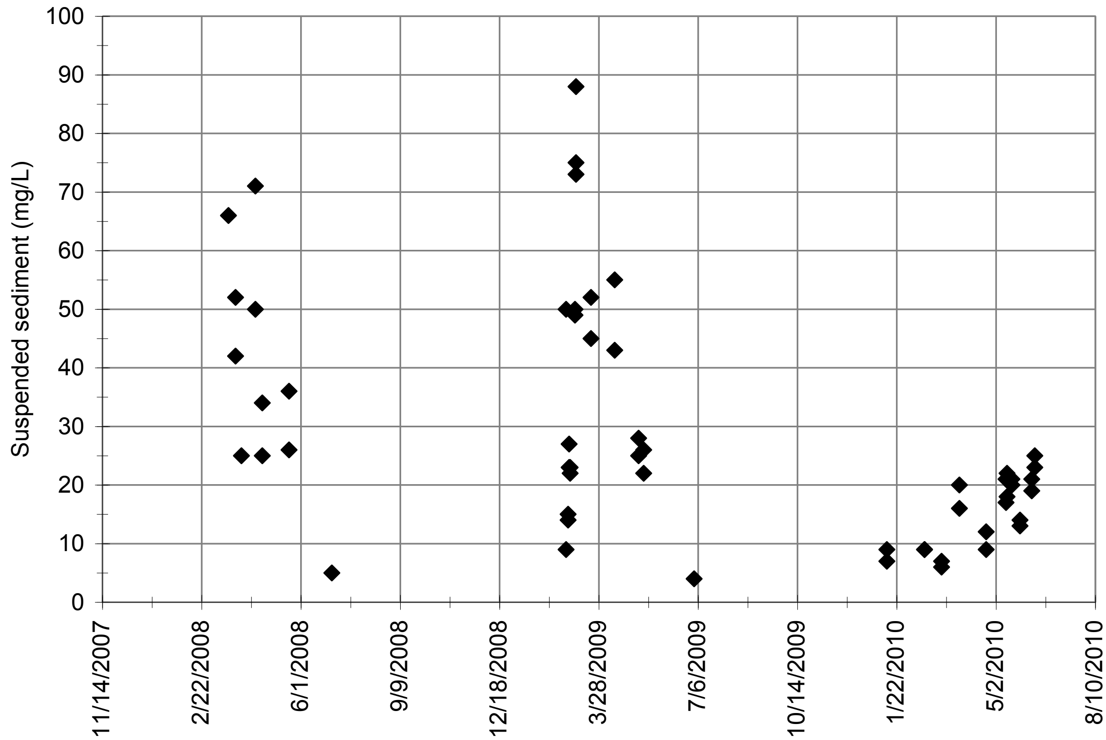


Figure C-6. Suspended Sediment (mg/L) Grab Samples for USGS Sprague River at Chiloquin (USGS Gage No. 11501000) 2008–2010. Source: USGS 2011 (http://waterdata.usgs.gov/nwis)

Campbell et al. (1993) examined TSS levels in the mainstem Wood River and report highly variable concentrations of 0–1.41 mg/L in the headwaters at Dixon Road and 0.6-5.88 mg/L at the mouth near Agency Dike Road. Available data indicate that turbidity in the Wood River averages 0.65 NTUs at the headwaters and 1.0–4.5 NTUs at the mouth (Campbell et al. 1993).

C.2.1.2 Upper Klamath Lake

While not focused on suspended materials per se, a variety of studies indicate that fine sediment delivery to Upper Klamath Lake has been relatively high during the 20th century. Suspended sediment inputs to Upper Klamath Lake have been examined using isotopic dating studies of sediment cores to determine the historical timing and potential sources of sediments to the lake. Using lead isotopic ratios (^{210}Pb:^{206}Pb), Eilers et al. (2004) demonstrate an increase in sediment accumulation rates in Upper Klamath Lake from 3 to 22 grams per square meter per year from the early to late 20th century. High titanium and aluminum concentrations in upper layers of lake sediments further indicate accelerated erosional inputs associated with 20th century watershed disturbances (Eilers et al. 2004). Gearhart et al. (1995) estimate 932 acre-feet per year of reduction in lake volume due to the sediment accumulation between 1920 and 1980.

Bradbury et al. (2004) suggest that a combination of wetland draining and channelization of tributaries to Upper Klamath Lake have increased erosion in the watershed during the 20th century.

Additionally, Eilers et al. (2004) report higher isotopic ratios of nitrogen (^{15}N:^{14}N) in 20th century sediment deposits in Upper Klamath Lake, indicative of nonpoint sediment source inputs of nitrogen-based fertilizers (Fry 1999, as cited in Eilers et al. 2004). A significant increase in ^{15}N after the completion of the Link River Dam at the outlet of Upper Klamath Lake in 1921 suggests that large inputs from nonpoint sediment sources in the upper watershed have occurred (Eilers et al. 2004). Based on sediment core analyses by Eilers et al. (2004), the construction and operation of Link River Dam appears to have altered the timing and quantity of lake flushing flows. The dam may also have contributed to alterations in nutrient retention dynamics in Upper Klamath Lake (as evidenced by the increased ^{15}N:^{14}N ratios) concurrent with the increased nutrient loading due to anthropogenic activities in the basin.

C.2.1.3 Link River Dam to Klamath River Upstream of J.C. Boyle Reservoir

Between Link River at Klamath Falls (RM 253.1) and the upstream end of J.C. Boyle Reservoir (RM 224.7), suspended sediment and turbidity concentrations decrease longitudinally, as algae are exported from Upper Klamath Lake and into the quiescent, relatively long residence time (approximately 4 to 12 days [Sullivan et al. 2011]) waters of Lake Ewauna and the Keno Impoundment, where they largely settle out of the water column (see also chlorophyll-*a* discussion in Section C.6.1.3). Data from June through November during 2000-2005 indicate that the largest relative decrease in mean TSS in the upper Klamath River occurs between Link River Dam and Keno Dam (Figure C-7, Raymond 2008), where mean values dropped from approximately 14 mg/L at Link River at Klamath Falls (RM 253.1) to near 8 mg/L at Keno Dam (RM 233.0). Values in individual years generally conform to this pattern, although year to year variability in the trend is apparent (PacifiCorp 2004a, Raymond 2008, 2009, 2010).

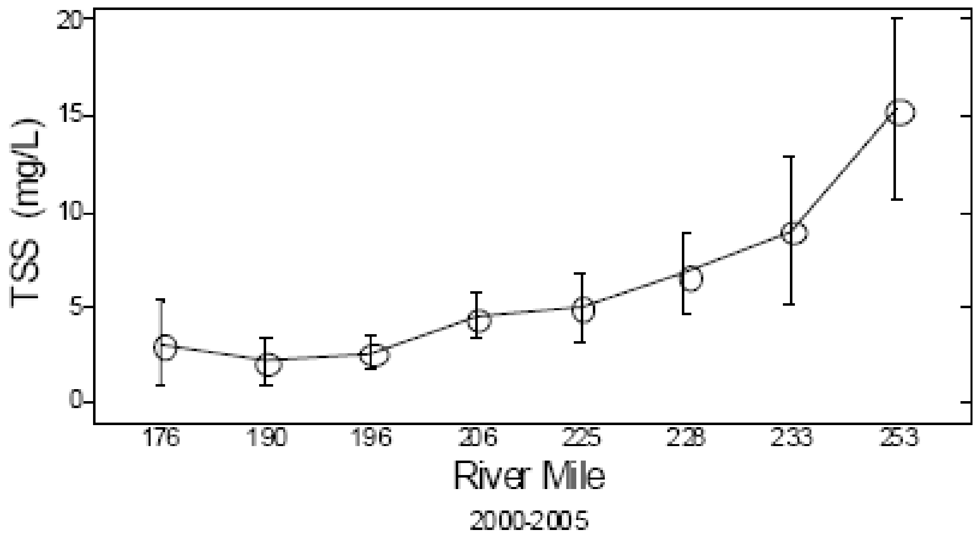


Figure C-7. Mean Total Suspended Solids (TSS) Values for Data Collected from Various Sites in the Klamath River Between 2000 and 2005. Error bars depict 90 percent confidence interval of the mean. Iron Gate Dam (RM 190.1), Copco 1 Dam (RM 198.6), J.C. Boyle Dam (RM 224.7), Keno Dam (RM 233), Link River Dam (RM 253), Source: Raymond 2008.

During summer months, peak values of TSS in this reach are associated with algal blooms from Upper Klamath Lake (PacifiCorp 2004a). Concurrent data from 2003, including chlorophyll-*a*, TSS and turbidity, indicate that elevated organic suspended sediments and turbidity levels are associated with high concentrations of algae (specifically cyanobacteria) downstream of Link River at Lake Ewauna (RM 253.1) in this reach during summer months (PacifiCorp 2004a). Samples collected at Link River mouth (RM 253.1) during July, August, and September 2003 exhibit algal (*Aphanizomenon flos-aquae*) concentrations greater than 20 cubic millimeters per liter (Kann and Asarian 2006), maximum turbidity of 22.5 NTU, and maximum TSS of 46 mg/L (PacifiCorp 2004a). Earlier and later in the summer of 2003, lower suspended sediment and turbidity levels correspond to lower algal levels in the river upstream of J.C. Boyle Dam (RM 224.7). Data from May to October 2005 indicate that suspended sediments in the Keno Impoundment (including Lake Ewauna) (RM 233-253.1) ranges from 2 to 21 mg/L, with concentrations increasing through the spring and reaching a maximum in early summer (Deas and Vaughn 2006). More recent data collected in 2009 for the Keno Impoundment at Miller Island (RM 246) indicate a summer peak in TSS of 17 mg/L (Watercourse Engineering, Inc. 2011).

C.2.1.4 Hydroelectric Reach

Moving downstream, suspended sediments generally continue to decrease through the Hydroelectric Reach. During the winter and spring (November through April), the reservoirs at the Four Facilities intercept and retain mineral (inorganic) sediments delivered from tributaries to the reservoirs (i.e., Shovel Creek, Fall Creek, Jenny Creek), where peak concentrations occur in association with high-flow events. While this may be somewhat beneficial for downstream reaches by decreasing suspended sediment concentrations and turbidity, the interception of mineral (inorganic) sediments by the reservoirs does not appear to be an important mechanism related to sediment delivery in the mainstem Klamath River. This is because a relatively small (3.4 percent) fraction of total sediment supplied to the Klamath River on an annual basis originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (Stillwater Sciences 2010) and beneficial uses in the upper Klamath River are currently not impaired due to mineral (inorganic) suspended material (see Section 3.2, Table 3.2-8).

During the growth season (May through October), algal-derived (organic) suspended materials exhibit a general downward longitudinal trend in the Hydroelectric Reach, although the relative decrease through this reach is less than that occurring further upstream in the Keno Impoundment, where algal blooms originating in Upper Klamath Lake largely settle out of the water column (see Figure C-7 and prior discussion in Section C.2.1.3). Further decreases in concentrations of algal-derived (organic) suspended materials can occur in the Hydroelectric Reach, which may be due to the mechanical breakdown of algal remains and sorting of progressively smaller sizes of natural organic matter (NOM) in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, as well as by dilution from the springs downstream of J.C. Boyle Dam.

Despite the mechanisms supporting decreased longitudinal concentrations of algal-derived (organic) suspended materials in the riverine portions of the Hydroelectric Reach, concentrations in this reach can also increase due to large seasonal algal blooms occurring in Copco 1 and Iron Gate Reservoirs. TSS values in Copco 1 Reservoir during the growth season (May through October) typically range <2–20 mg/L and those in Iron Gate Reservoir range <2–14 mg/L, although intense algae blooms can result in TSS levels greater than 20 mg/L (Raymond 2008, 2009, 2010). During 2003 sampling by PacifiCorp, a particularly high TSS measurement of 280 mg/L was recorded in the epilimnion of Copco 1 Reservoir during May. Simultaneous measurements of suspended materials measured in the outflow to the reservoir indicated only 4.8 mg/L TSS (FERC 2007), suggesting that the suspended materials source (algal cells) had largely settled out of the water column within the reservoir. Since powerhouse withdrawals for Copco 1 and Iron Gate Dams are from depths of approximately 6 m (20 ft) to 12 m (39 ft) below the water surface when the reservoirs are full (Section C.1.1.4), only portions of the extensive algal blooms positioned closer to the water surface may be transported to the downstream Klamath River. During 2009 water quality monitoring, total suspended sediments measured in J.C. Boyle Reservoir ranged <2–6.8 mg/L from May through November. Levels in Copco 1 and Iron Gate reservoirs levels were somewhat greater, with suspended sediments ranging <2–9.6 mg/L in Copco 1 Reservoir (peak in August) and <2–7.2 mg/L in Iron Gate Reservoir (peak in May) (Watercourse Engineering, Inc. 2011).

Estimates of the volume of sediment deposits stored within J.C. Boyle, Copco 1 and 2, and Iron Gate Reservoirs include 13.1 million cubic yards (yd^3) (Greimann et al. 2011), 14.5 million yd^3 (Eilers and Gubala 2003), and 20.4 million yd^3 (Gathard Engineering Consultants 2006). Sediment texture analysis results of the current reservoir deposits indicate that the deposits are composed of predominantly fine material (e.g., silt and clay <0.0625 mm [Gathard Engineering Consultants 2006]; see also Section 3.11 of this Klamath Facilities Removal EIS/EIR) with 3 to 5 percent of the accumulated material as organic carbon, corroborating interpretation of longitudinal suspended sediment patterns and indicating that in-reservoir and upstream algal growth is largely intercepted and retained in reservoir sediments in the Hydroelectric Reach.

C.2.2 Lower Klamath Basin

C.2.2.1 Iron Gate Dam to Salmon River

Immediately downstream of Iron Gate Dam (RM 190.1), mineral (inorganic) suspended materials tend to increase with distance downstream of the dam during winter months. On an annual basis, two of the three tributaries that contribute the largest amount of sediment to the Klamath River are in this reach; the Scott River (607,300 tons per year or 10 percent of the cumulative average annual delivery from the basin), and the Salmon River (320,600 tons per year or 5.5 percent of the cumulative average annual delivery from the basin) (Stillwater Sciences 2010). The Scott River enters the mainstem Klamath River at RM 143 and is listed as impaired under Section 303(d) of the CWA for sedimentation (see Section 3.2, Table 3.2-8).

During the growth season (May–October), suspended materials immediately downstream of Iron Gate Dam are relatively lower than upstream locations, with generally low (<5-8 mg/L) concentrations for 2000–2005 (PacifiCorp 2004a; Raymond 2008, 2009, 2010) (Figure C-7). Between Iron Gate Dam and Seiad Valley (RM 129.4), suspended materials can increase; for example TSS concentrations near the Shasta River confluence (RM 176) for the period 2000-2005 were roughly 1 mg/L greater than those measured further upstream at Iron Gate Dam (Figure C-7), and during 2009 monitoring, TSS ranged 0.87–4.4 mg/L downstream of Iron Gate Dam (RM 190.1), increasing to 2.5-11.5 mg/L downstream of Seiad Valley (RM 129.4) (Watercourse Engineering, Inc. 2011)[1]. This pattern may be related to the transport of some portion of the in-reservoir algal blooms to downstream reaches of Klamath River. River bed scour may also cause resuspension of previously settled materials and increases in summer and fall TSS from 0 to 20 miles downstream of the dam (Figure C-8). Further downstream, near the confluence with the Scott River (RM 143.0) concentrations of suspended materials tend to decrease with distance as suspended materials gradually settle out of the water column

[1] This data set includes measurements in November and December 2009 as well.

farther downstream or are diluted by tributary inputs (Armstrong and Ward 2008). Chlorophyll-*a* data show a similar trend (see Section C.6.2.1).

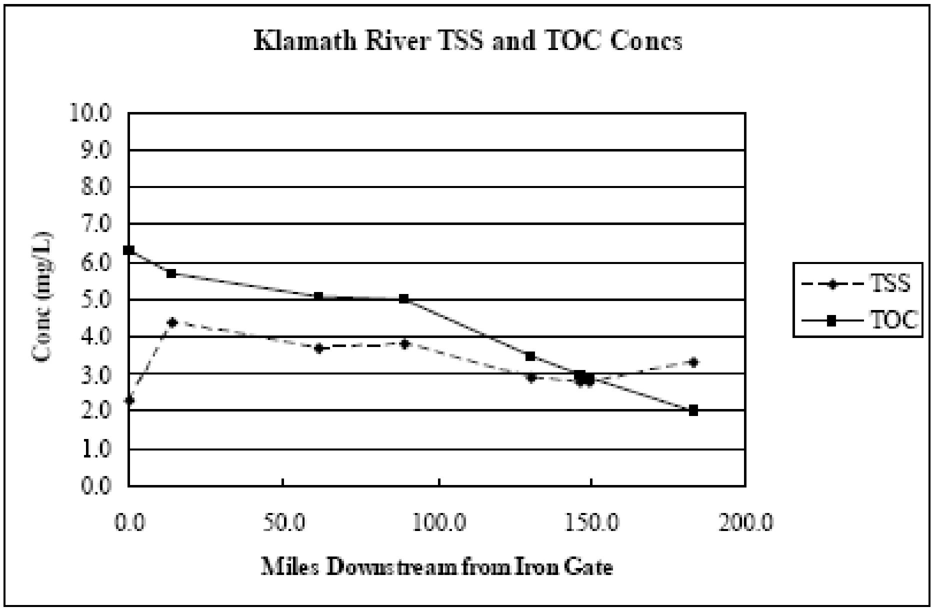


Figure C-8. Average TSS and Total Organic Carbon in the Klamath River Downstream of Iron Gate Dam during June–October 2001–2005. Source: Armstrong and Ward 2008.

C.2.2.2 Salmon River to Estuary

As in other reaches of the Klamath River, seasonal variation in turbidity and suspended materials is evident in the Klamath River from the Salmon River (RM 66.0) to the Estuary (RM 0–2), with peak summer turbidity values associated with organic matter (i.e., algae blooms) and peak spring and winter turbidity values associated with inorganic sediments that are mobilized during high flow events (Stillwater Sciences 2009). The lower Klamath River from the Trinity River (RM 42.5) to the Estuary (RM 0–2) and multiple tributaries downstream of the Trinity River are listed as impaired under Section 303(d) of the CWA for sedimentation (see Section 3.2, Table 3.2-8) (NCRWQCB 2010, State Water Resources Control Board [SWRCB] 2010a).

Historical (1950–1979) suspended sediment data for the Klamath River at Orleans (RM 59) (USGS gage no.11523000) range from less than 5 mg/L during summer (low-flow) periods to greater than 5,000 mg/L during winter (high-flow) periods, although some high (>1,000 mg/L) suspended sediment events have occurred during summer months (e.g., 1974, see Figure C-9). More recent data indicate that suspended material levels in the lower Klamath River from the Salmon River confluence (RM 66.0) to the Estuary (RM 0–2) can be similar to those measured in the upstream reach from Iron Gate Dam to the Salmon River (RM 66). Results from grab samples collected by the Yurok Tribe Environmental Program during the period 2003–2004 indicate that TSS ranged

<1.0-3.2 mg/L upstream of the Trinity River (RM 42.5) and <1.0–14.0 farther downstream at Turwar (RM 5.8), with the peak value (14.0 mg/L) occurring in December 2003 (YTEP 2005). However, the majority of the grab samples were collected from June to September and only two grab samples were collected in December and January. The data exhibit similar values for 2007, with the highest TSS (up to 16.0 mg/L) observed at Turwar in September of that year (Fetcho 2007). During 2009 monitoring, TSS values measured at Orleans were generally 1.1–13.3 mg/L between May and December, with peak values (≈56 mg/L) occurring during October (Watercourse Engineering, Inc. 2011).

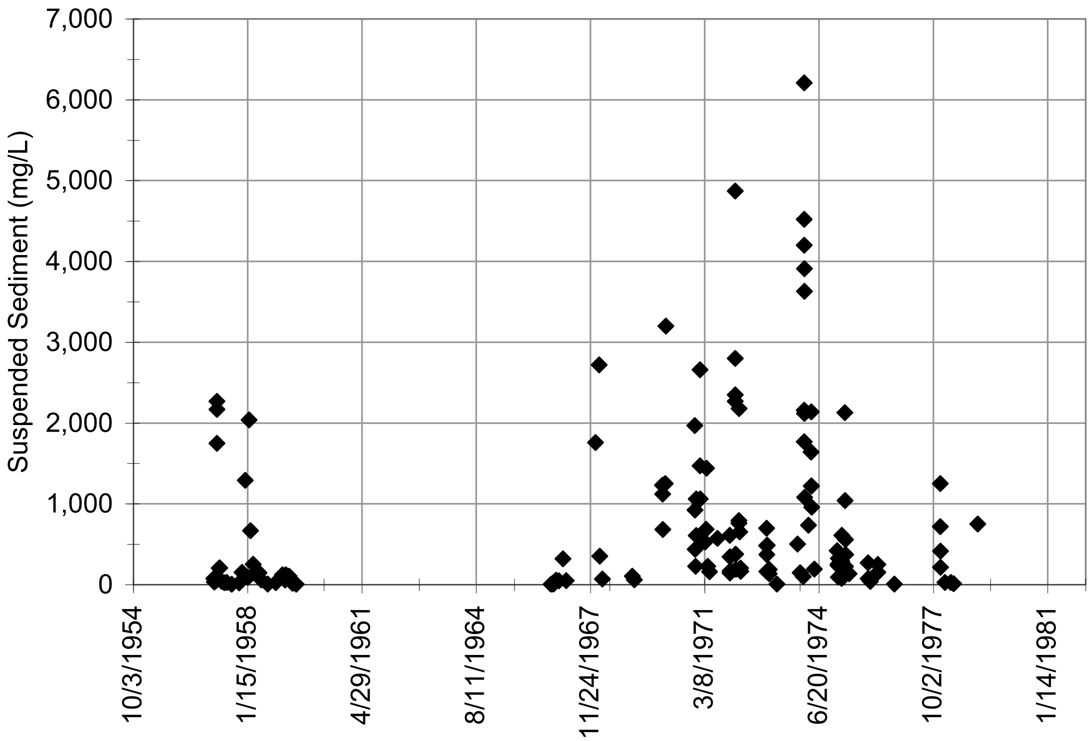


Figure C-9. Suspended Sediment (mg/L) Grab Samples for USGS Klamath River at Orleans (USGS Gage No. 11523000) (RM 59) 1950–1979. Source: USGS 2011 (http://waterdata.usgs.gov/nwis)

The Trinity River contributes 3,317,300 tons per year of sediment to the lower Klamath River or 57 percent of the cumulative average annual delivery from the basin (Stillwater Sciences 2010). Mass wasting, bank erosion, and other natural erosion processes contribute a large portion of the total fine sediment supply to the lower Klamath River, along with management activities such as timber harvest and road construction along tributaries (United States Forest Service 2004, Stillwater Sciences 2010). When combined with the steep terrain, granular soil matrix, and high precipitation, these sources may be a primary contributor to fine sediment deposits found in deep pools near cultural sites in the lower Klamath River (FERC 2007).

C.2.2.3 Klamath Estuary

Available historical (1958–1996) suspended sediment data for the Klamath River at Klamath Glen (RM 7) (USGS gage no. 11530500) indicates values of less than 5 mg/L during summer (low-flow) periods to greater than 500 mg/L during winter (high-flow) periods, although one high (>750 mg/L) suspended sediment event appears to have occurred during the early fall (i.e., October 1977, see Figure C-10).

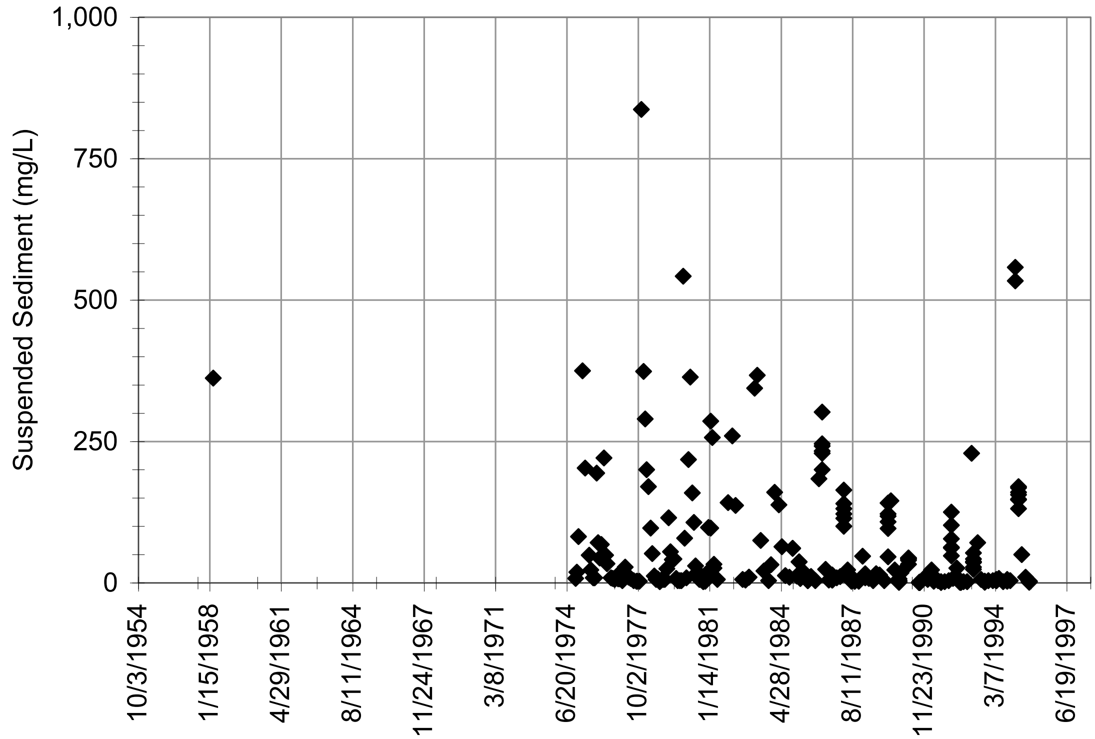


Figure C-10. Suspended Sediment (mg/L) Grab Samples for USGS Klamath River near Klamath (USGS Gage No. 11530500) (RM 7) 1958–1995. Source: USGS 2011 (http://waterdata.usgs.gov/nwis)

An analysis of more recently collected TSS data in the Klamath Estuary indicates that TSS are variable but generally similar to those measured at upstream sites in the lower Klamath River (YTEP 2005, Sinnott 2007). For 2003–2004, TSS levels were <1.0-3.2 mg/L for surface waters in the mid- and lower-estuary, and slightly greater (1.8-10.0 mg/L) at depth (YTEP 2005). During May–December 2009, measured TSS levels were generally 2.1–12.7 mg/L, with the peak value (17.9 mg/L) occurring in May (Watercourse Engineering, Inc. 2011). Turbidity measurements in small tributaries (e.g., McGarvey, Den, Blue, and Turwar Creeks) immediately upstream or within a few river miles upstream of the estuary exhibit peak values during winter high flow periods (i.e., storm events), with measured values exceeding 500 NTU during December through February 2004 (YTEP 2005). During late spring through early fall, when average rates of precipitation in the Klamath Basin are relatively lower, inorganic (mineral) suspended sediments and turbidity in the Klamath Estuary are generally lower as well.

Algal blooms within and upstream of the estuary have the potential to cause large spikes in turbidity and organic suspended sediments in the estuary. This occurred during the extensive algal bloom detected throughout at least 40 river miles of the lower Klamath River in September 2007 (Kann 2007a–2007d). In the lower estuary, increases in nutrient levels and algae concentrations were correlated with an increase in TSS from 2.2 mg/L on August 21, 2007 to 9.0 mg/L on September 18, 2007, and increases in nutrients, algae levels, and TSS during that period were measured as far upstream as Iron Gate and Copco 1 reservoirs (Asarian et al. 2009). Thus, the observed 2007 increase in estuarine TSS appears to have been influenced by algal growth originating in the two largest reservoirs in the Hydroelectric Reach.

C.3 Nutrients

Nutrients are critical for the support of primary productivity (i.e., plant growth) in both terrestrial and aquatic ecosystems. High levels of nutrients (nitrogen and phosphorus) in lakes and rivers have the potential to impact overall water quality by increasing rates of algal growth and decay, which can lead to increased levels of turbidity, large fluctuations in dissolved oxygen and pH levels, as well as potential increases of toxic substances such as ammonia (NH_4^+/NH_3), hydrogen sulfide (H_2S), and release of heavy metals from low oxidation-reduction potential at the sediment water interface (see Section 3.2.3.1 for additional background information on water quality processes in the Klamath Basin). Dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) can be used directly by algae, whereas particulate nutrients (e.g., organic phosphorus, organic nitrogen) are not readily bioavailable for most algal species.

Volcanic activity has dominated the geology of Upper Klamath basin for the past 35 million years. Consequently, relatively high levels of phosphorus are present in Upper Klamath Basin's volcanic rocks and soils. Erosion is currently understood to be the major process by which sediment-associated particulate phosphorus is delivered from the upper sub-basins of the Wood, Williamson, and Sprague Rivers to Upper Klamath Lake (ODEQ 2002). During peak flows, particulate phosphorus has been observed to increase to 60 percent of the total phosphorus (TP) load compared to less than 5 percent during summer low flows (Kann and Walker 1999). The observed seasonal increase in particulate phosphorus loading and increase in volume-weighted concentration of TP during high flows may be indicative of degraded watershed conditions (Kann and Walker 1999), where land uses including road building, forestry, grazing and agriculture have altered upland and riparian plant communities and subsequently increased contribution of phosphorus through erosion to Upper Klamath Lake (DEA 2005). Based on available information, local watershed groups have suggested that insufficient data exists to clearly demonstrate the proportion of TP loading due to natural sources and the proportion due to degraded riparian conditions and increased water yields (Connelly and Lyons 2007, Rabe and Calonje 2009). However, research published in peer reviewed journals demonstrates that although levels of naturally occurring phosphorus are elevated in Upper Klamath Lake, historical land use activities in the Upper Klamath Basin resulted in increased nutrient loading to the lake, subsequent changes in its trophic status, and associated degradation of water quality (Bradbury et al. 2004, Eilers et al. 2004). Nitrogen sources to the lake have been identified as upland erosion, return flows from agricultural lands, and *in situ* nitrogen fixation by cyanobacteria (ODEQ 2002).

C.3.1 Upper Klamath Basin

C.3.1.1 Wood, Williamson, and Sprague Rivers

Based on the mass balance conducted for development of the Upper Klamath Lake TMDLs (ODEQ 2002), the Williamson River contributes an estimated 20.5 percent (10.8 kilograms per square meter per year [$kg/km^2/yr$]) of the external phosphorous load to Upper Klamath Lake, the Sprague River contributes 26.5 percent (11.5 $kg/km^2/yr$), and the Wood River contributes 19.1 percent (90 $kg/km^2/yr$) (Kann and Walker 1999). The Sprague River exhibits a high correlation between river flows and phosphorus loading, particularly during runoff events, suggesting that runoff from peak flow events delivers a significant source of suspended and particulate phosphorus to the Williamson River and subsequently, Upper Klamath Lake (ODEQ 2002). Upland contributions to the TP load are generally bound phosphorus and are associated with peak flows and suspended sediments (Gearhart et al. 1995, McCormick and Campbell 2007).

Agricultural return flows from former wetlands along the Wood River appear to contribute relatively high concentration of phosphorus to Upper Klamath Lake; upstream of former wetlands on the Wood River, the phosphorus load is approximately 64.9 $kg/km^2/yr$, while downstream it increases to 237 $kg/km^2/yr$ (Kann and Walker 1999). Large increases in TP in the Wood River occur from January to June, corresponding to pumping/drainage of the surrounding inundated lands for grazing and agricultural uses, and peak seasonal runoff (ODEQ 2002).

The estimated TN load of the Williamson River, excluding loads contributed by the Sprague River, is 111 metric tons per year (MT/yr) (Walker 2001). The Sprague River TN load is estimated at 237 MT/yr (Walker 2001). Data collected during 1999–2005 in the upper Sprague River subbasin and 1991–2005 in the lower Sprague-lower Williamson river sub-basins indicate that nitrate is consistently below 0.38 mg/L, the evaluation criteria adopted for watershed assessments in Oregon (ODEQ 2006 as cited in Connelly and Lyons 2007; Klamath Tribes Natural Resource Department 2006 and USGS 2007 as cited in Rabe and Calonje 2009, Watershed Professionals Network 1999)

C.3.1.2 Upper Klamath Lake

Based on the mass balance conducted for development of the Upper Klamath Lake TMDLs, the TP budget for Upper Klamath and Agency Lakes averages 466 MT/yr; external sources supply roughly 40 percent of TP (182 MT/yr) and internal sources supply roughly 60 percent (285 MT/yr; ODEQ 2002, Kann and Walker 1999). Identified external sources include 1) atmospheric deposition, 2) fluvial sources from tributaries, and 3) diffuse sources such as springs and marshes (ODEQ 2002). Within these external sources, springs that contribute to the base flow of tributaries to Upper Klamath Lake carry a naturally high background of soluble phosphorus ranging from 0.05 to 0.09 mg/L (Gearhart et al. 1995). Agricultural return flows from former wetlands, while contributing only 3 percent of the annual flow into the lake, account for 15 percent of external phosphorus loading (Kann and Walker 1999). The estimated median unit area contribution for agricultural return flows is 220 $kg/km^2/yr$. Former wetlands, drained and diked for agricultural purposes, contain peat soils that decompose under the aerobic conditions of the wet and dry cycles associated with agriculture and release high concentrations of phosphorus (Snyder and Morace 1997).

Seasonal changes in lake TP have been reported by Rykbost and Charlton (2001) and Kann and Walker (1999); spring runoff causes an initial seasonal increase in TP levels in Upper Klamath Lake as phosphorus bound to sediments is transported into the lake. A second increase in phosphorus occurs from June–September due to algal growth and decay cycles; algal blooms incorporate phosphorus into biomass and after a bloom crash occurs, they release soluble reactive phosphorus back into the lake. Dissolved ammonium can also be released following algal bloom crashes. Blooms of the nitrogen-fixing cyanobacteria species, *A. flos-aquae,* in Upper Klamath Lake appear to be phosphorus limited. However, water column samples collected during the annual *A. flos-aquae* bloom in April, May, and August 2006 suggest that iron limitation may play a role in primary productivity in the lake and should be further investigated. Study results suggest that dissolved iron became depleted in the lake water column during the course of 2006 seasonal algal bloom, while dissolved ammonium and soluble reactive phosphorus (SRP) increased (Kuwabara et al. 2009). However, there were no samples collected during the primary bloom period and the study did not account for the low SRP during the initial bloom growth period, suggesting that iron may play a role but it is not likely to be the primary driver for limiting algal growth in Upper Klamath Lake; the more prominent pattern is one of phosphorus limitation during bloom development (e.g., Kann 2010, Lindenberg et al. 2009).

The Total Nitrogen (TN) balance conducted for development of the Upper Klamath Lake TMDLs indicates that the lake is a seasonal source of nitrogen to Link River, with export rate estimates at 234.5 kg/km^2 (Kann and Walker 1999, ODEQ 2002). Internal lake sources of nitrogen appear to exceed external sources given available data, where the main source of increased internal nitrogen loading is nitrogen fixation by the cyanobacteria species, *A. flos-aquae* (Kann and Walker 1999). Regeneration of nitrogen from lake sediments is another identified internal source of nitrogen to Upper Klamath Lake (Kuwabara et al. 2009). Identified external sources of nitrogen to Upper Klamath Lake include tributaries, native soils, precipitation, agricultural pumps, and springs (Kann and Walker 1999, McCormick and Campbell 2007).

While both phosphorus and nitrogen concentrations have increased in Upper Klamath Lake over the past 100 years, increases in these nutrients have not necessarily occurred in the same proportions (Eilers et al. 2004). A significant decrease in the nitrogen to phosphorus (N:P) ratio in recent sediment layers has been observed and is likely the result of either a decrease in N-fixing algae or an increase in phosphorus loading from external sources. As there is an abundant presence of N-fixing algae in the lake, it is more likely that phosphorus loading has increased over time relative to nitrogen loading (Eilers et al. 2004). The relative increase in phosphorus over nitrogen (i.e., decreasing N:P) favors N-fixing cyanobacteria such as *A. flos-aquae* , which currently contribute to heavy algal blooms in Upper Klamath Lake.

C.3.1.3 Link River Dam to Klamath River upstream of J.C. Boyle Reservoir

Historical (1950–2001) TP data indicate median values of 0.072–2.1 mg/L in the Upper Klamath Basin between Link River Dam and J.C. Boyle Reservoir, with the highest median values occurring at RM 228, which is at the upstream end of J.C. Boyle Reservoir (Figure C-11). Variability over the long-term record in this reach is high, with multiple outlying data points above and below the 95th percentile and indicating TP levels greater than 3 mg/L at multiple sites in the reach. The historical record indicates less overall variability in orthophosphate concentrations in the reach, but still some relatively high concentrations (≈3 mg/L) occurring just downstream of Link River Dam (RM 253) (PacifiCorp 2004b). A review of water quality data near Klamath Straits Drain (RM 240.5) from 1991–1999 also documented elevated concentrations of total phosphorus, with mean concentrations across the monitoring period of 0.41 mg/L at Stateline Highway (Lytle 2000).

Phosphorus data collected in a more recent study from April to November 2007 from just downstream of Link River Dam (RM 253.2) to Keno Dam (RM 234.9) range from 0.05 to 0.50 mg/L for TP and from 0.01 to 0.27 mg/L for filtered orthophosphate (Sullivan et al. 2008); both nutrient concentrations increase from spring to summer and decrease into fall months (Sullivan et al. 2008, Deas and Vaughn 2006). During the 2007 study, orthophosphate concentrations appeared to increase in a downstream direction from the Link River Dam to the downstream end of the Keno Impoundment (Deas and Vaughn 2006). In a recent study of nutrient dynamics in the Klamath River, May through November TP and orthophosphate (reported as SRP) for 2005–2008 follow a decreasing longitudinal pattern, with the highest concentrations (approximately 0.1-0.5 mg/L) measured in the Klamath River downstream of Keno Dam (RM 228–233) (Asarian et al. 2010, Watercourse Engineering, Inc. 2011). Downstream of Keno Dam, orthophosphate concentrations are highly variable, and there appears to be substantial conversion of phosphorus from particulate to dissolved forms in the turbulent section of river between Keno Dam and J.C. Boyle Reservoir (Asarian et al. 2010, Deas 2008). For April to November 2007, peak TP concentrations in this reach tend to occur between July and September (variable by year), declining through the remainder of the fall months (Asarian et al. 2010). A recent study on nutrient cycling the Lower Klamath National Wildlife Refuge indicates that refuge wetland management is simultaneously reducing nutrient loads and increasing the proportion of bioavailable P in wetland outflows, which then enter the Klamath River through the Klamath Straits Drain (RM 240.5) (Mayer 2005).

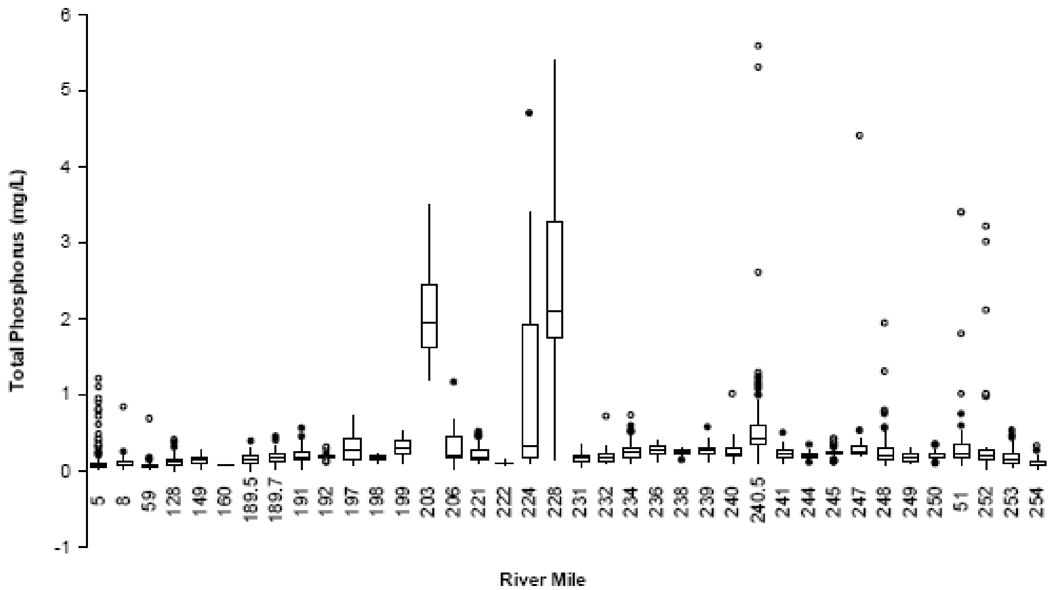


Figure C-11. Box and Whisker Plot of Historical TP Data Collected from Various Sites in the Klamath River from Klamath River at Klamath Glen (RM 5) to Klamath River at Link River Dam (RM 254) Between 1950 and 2001. Source: PacifiCorp 2004b.

Historical (1950–2001) nitrogen data is available as total Kjeldahl nitrogen (TKN; a measure of organic nitrogen plus ammonia), nitrate (NO_3^-) and ammonia (NH_4^+). TKN median values were 1.3–3 mg/L in the Upper Klamath Basin between Link River Dam and J.C. Boyle Reservoir, with the highest median values occurring at RM 240.5, which is just downstream of the Klamath Straits Drain (PacifiCorp 2004b). Variability over the long-term record in this reach is relatively high, with multiple outlying data points above the 95th percentile and indicating TKN levels greater than 5 mg/L at multiple sites in the reach. The historical record indicates similarly high variability in nitrate and ammonia concentrations in the reach, with some relatively high concentrations (>5 mg/L) occurring throughout the reach (PacifiCorp 2004b).

For the period April to November 2007, TN concentrations in the mainstem Klamath River collected from just downstream of Link River Dam (RM 253.2) to near Keno Dam (RM 234.9) range from 0.70 to 5.85 mg/L (Sullivan et al. 2008) with concentrations generally increasing from spring to summer (Sullivan et al. 2008, Deas and Vaughn 2006). Particulate nitrogen (presumably associated with organic particulate matter) concentrations range from 0.08 to 3.93 mg/L, also increasing from spring to summer and generally decreasing in a downstream direction (Sullivan et al. 2008). Average ammonia concentrations measured during April through November increase in a downstream direction (Sullivan et al. 2008, Deas and Vaughn 2006) from 0.089 mg/L at Link River, to 0.413 mg/L at Miller Island (RM 246) and 0.56 mg/L upstream of Keno Dam (RM 234.9, Sullivan et al. 2008). Dissolved nitrite plus nitrate concentrations appear to follow a different seasonal cycle than most nutrients in the Klamath River, where concentrations are below the reporting level (0.06 mg/L) from late June through mid-August 2007, but are detectable on a site-specific basis in the spring, late summer and fall (Sullivan et al. 2008). In the Asarian et al. (2010) study of nutrient dynamics in the Klamath River, data collected from May 2005 to December 2008 indicate that the highest TN values (approximately 1–4 mg/L) are found downstream of Keno Dam (RM 233) as compared with sites farther downstream (a similar pattern was observed in the 2009 dataset [Watercourse Engineering, Inc. 2011]). For the 2005–2008 study period, peak TN and organic nitrogen concentrations in this reach tend to occur in September, with an additional July peak during 2008, and declining concentrations through the remainder of the fall months (Asarian et al. 2010), corresponding to general temporal trends in chlorophyll-*a* and blooms of cyanobacteria.

Total inorganic nitrogen (nitrate, nitrite, ammonia) concentrations follow a different trend, tending to be relatively low in May–June (<0.2 mg/L), increasing through July, and remaining high (1–1.1 mg/L) August through November (Asarian et al. 2010). Data collected during 2000 to 2002 indicates that 34 percent of ammonia samples in the Klamath Hydroelectric Project (KHP) reach, many of them from the Keno Impoundment (including Lake Ewauna) (i.e., 64 of 178 exceedances), exceeded levels that would be acutely toxic to fish (FERC 2007). Accordingly, the Klamath River in Oregon from RM 231.5 (just upstream of Keno Dam) to the Link River Dam (RM 253) is listed as impaired under Section 303(d) of the CWA for ammonia (see Section 3.2, Table 3.2-8). Ammonia levels just downstream of Keno Dam exceeded 1.0 mg N/L during at least one summer month each year from 2005 to 2008, and exceeded 1.5 mg N/L during August 2005 and 2008 (Asarian et al. 2010).

C.3.1.4 Hydroelectric Reach

The Klamath River from the California-Oregon state line to Iron Gate Dam (including Copco Lake Reservoir [1 and 2] and Iron Gate Reservoir) is listed as impaired under Section 303(d) of the CWA for nutrients (see Section 3.2, Table 3.2-8). Historical and contemporary nutrient data indicate that on an annual basis nutrients in the Hydroelectric Reach tend to be lower than those in the reach from Link River Dam to upstream of J.C. Boyle Reservoir (Figure C-11 through C-13), due to dilution from springs downstream of J.C. Boyle Reservoir and the settling of particulate matter and associated nutrients in the larger KHP reservoirs (PacifiCorp 2004a; FERC 2007, Butcher 2008, Asarian et al. 2009), while on a seasonal basis the TN and TP can increase in this reach due to release of nutrients to the water column during periods of seasonal hypolimnetic anoxia (Kann and Asarian 2006; Asarian and Kann 2006a, 2006b; Butcher 2008; Asarian et al. 2009, et al. 2010). In J.C. Boyle Reservoir (RM 224.7), the furthest upstream reservoir in this reach, concentrations of TN and TP measured between the inflow and outflow are typically similar, likely due to the shallow depth and short residence time characteristic of this impoundment (PacifiCorp 2006), indicating that relatively little nutrient retention occurs in this reservoir. Downstream of J.C. Boyle Dam, TN and TP concentrations generally decrease with distance, with both mean longitudinal concentrations (Raymond 2008, 2009, 2010; Watercourse Engineering, Inc. 2011) and

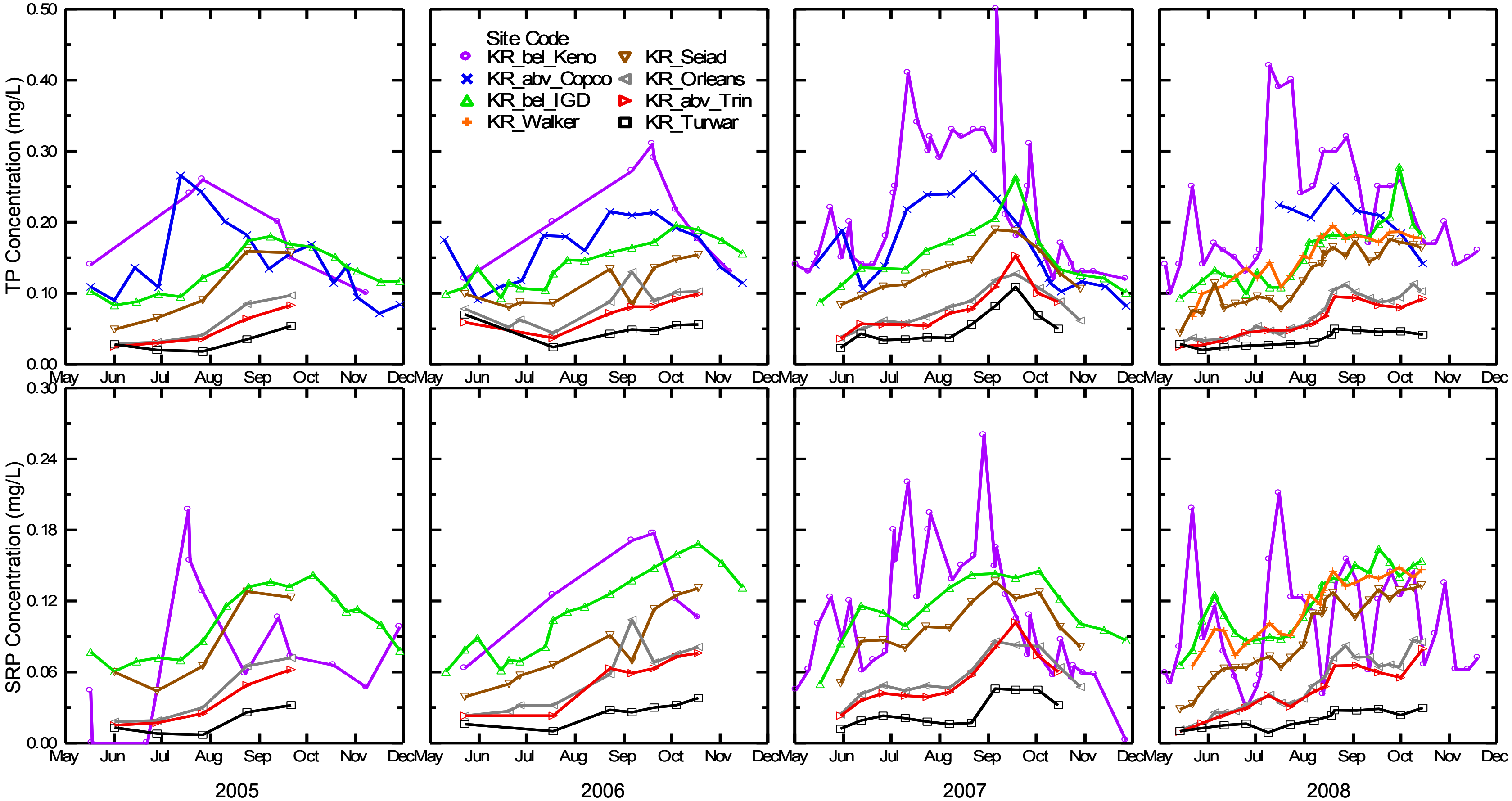


Figure C-12. Time Series of Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) Concentrations for Selected Mainstem Klamath Sites from Downstream of Keno Dam (≈RM 233) to Turwar (RM 5.8), May 2005–November 2008. Source: Asarian et al. 2010.

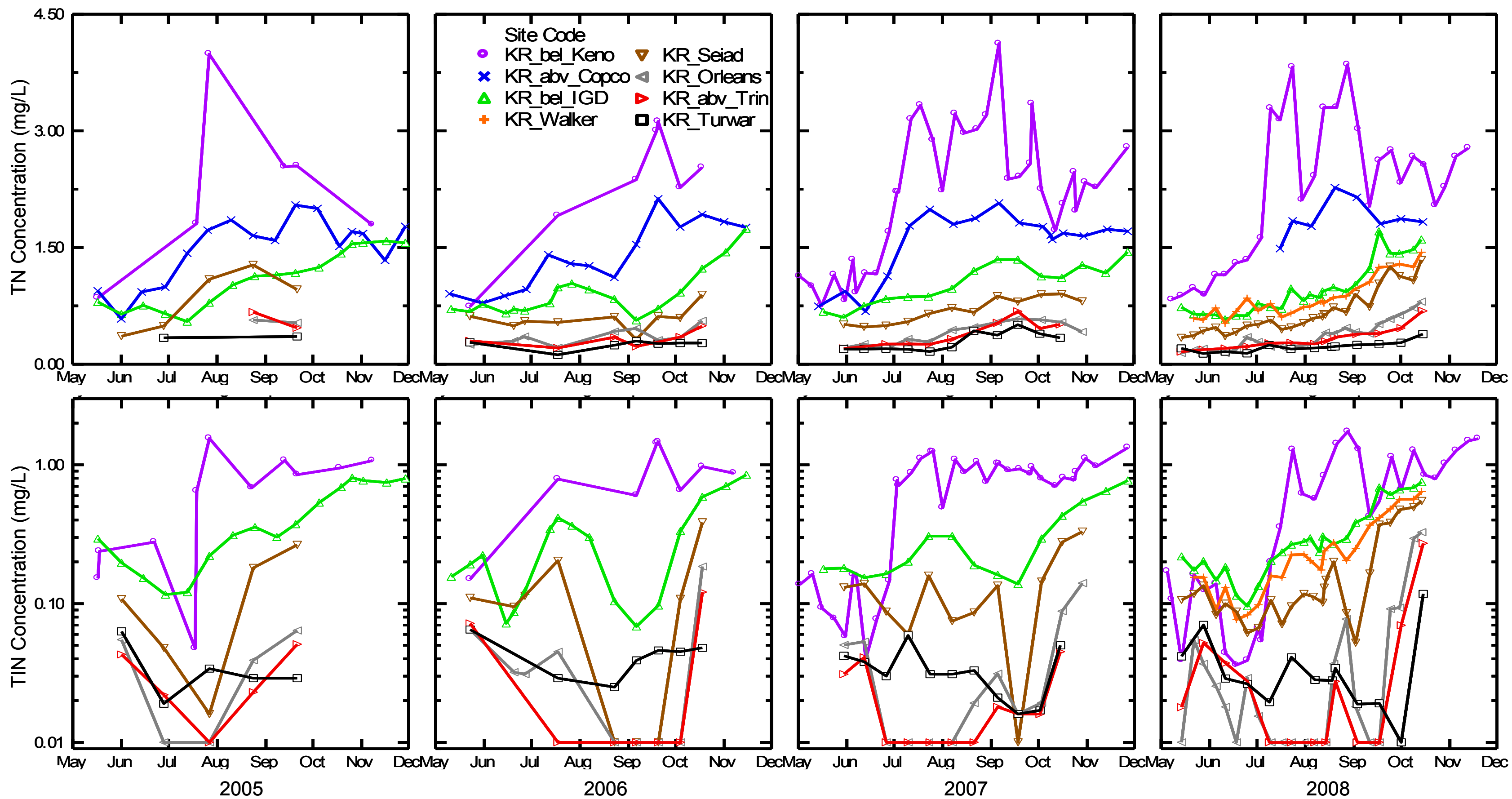


Figure C-13. Time Series of Total Nitrogen (TN) and Total Inorganic Nitrogen (TIN) Concentrations for Selected Mainstem Klamath Sites from downstream of Keno Dam (≈RM 233) to Turwar (RM 5.8), May 2005–November 2008. Source: Asarian et al. 2010.

flow-weighted longitudinal concentrations trending strongly downward through Copco 1 and Iron Gate Reservoirs, particularly for TN (see Figure C-14 and C-15 for flow-weighted concentration data; Asarian et al. 2009, et al. 2010). A frequent and notable exception occurs during August–November, when TP concentrations are often higher at Iron Gate Dam than they are at Keno Dam and upstream of Copco 1 Reservoir; this is likely due to the combination of internally-driven nutrient dynamics related to algal bloom crashes in Copco 1 and Iron Gate reservoirs and a 1–2 month temporal lag due to the longer hydraulic retention time of the reservoirs as compared to free-flowing river reaches (Kann and Asarian 2007, Asarian et al. 2009, et al. 2010, Watercourse Engineering, Inc. 2011).

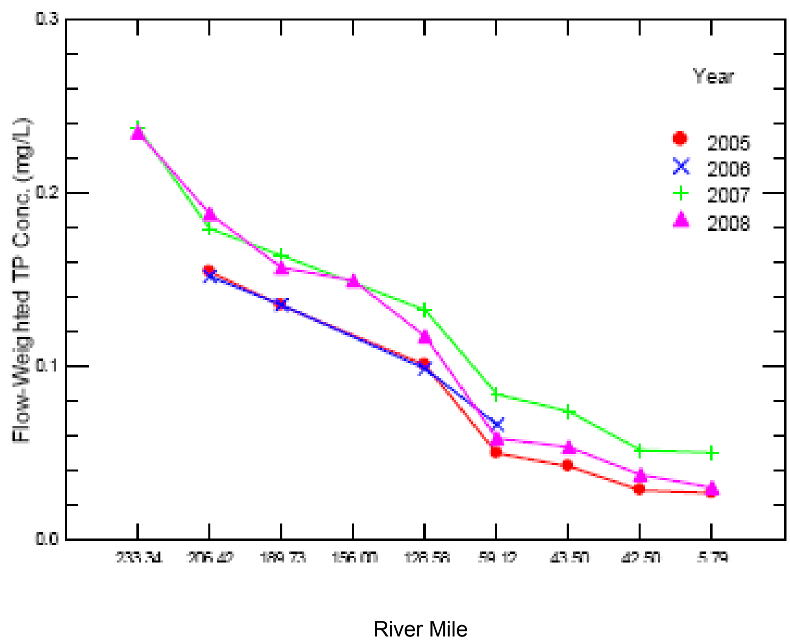


Figure C-14. Summary of Flow-Weighted Mean Concentration (mg/L) for TP at Mainstem Klamath River Sites from downstream of Keno Dam (≈RM 233) to Turwar (RM 5.8) for the Months of June–October (2005–2008). Source: Asarian et al. 2010.

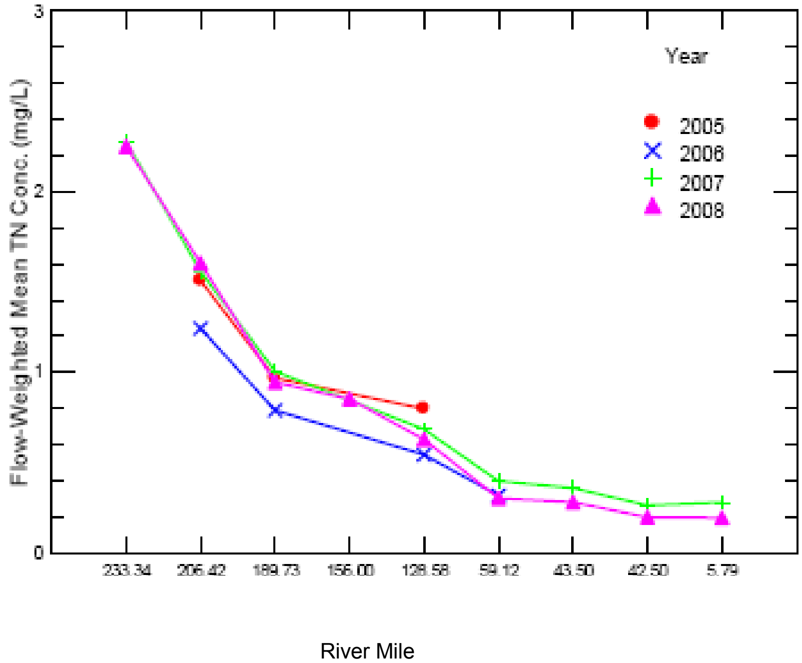


Figure C-15. Summary of Flow-Weighted Mean Concentration (mg/L) for TN at Mainstem Klamath River Sites from Downstream of Keno Dam (≈RM 233) to Turwar (RM 5.8) for the Months of June–October (2005–2008). Source: Asarian et al. 2010.

While annual data from 2000 through 2004 and early modeling studies by PacifiCorp conducted for the FERC relicensing process indicates that Copco 1 and Iron Gate Reservoirs act primarily as TN and TP sinks due to trapping of algal detritus (PacifiCorp 2004a, FERC 2007), subsequent analyses found that while overall annual retention is likely occurring, the KHP reservoirs can also serve as seasonal sources of TN and TP (though far less for TN than for TP) through the release of nutrients from reservoir sediments into the water column during periods of algal decomposition and seasonal hypolimnetic anoxia, and possibly through direct nitrogen fixation from the atmosphere by cyanobacteria (Kann and Asarian 2005, 2006; Asarian and Kann 2006a, 2006b; Butcher 2008; Asarian et al. 2009, et al. 2010). Data presented in Asarian et al. (2009) suggest that much of the TP released from Copco 1 and Iron Gate reservoir sediments during summertime anoxia remains in the hypolimnion until the reservoirs begin to turn over in the fall, rather than being released to downstream river reaches during the summer period of peak periphyton growth. However, in many years TP concentrations during August through October have been observed to be higher downstream of Iron Gate Dam than upstream of Copco 1 Reservoir corresponding to peak in-reservoir algal blooms and indicating that some release of TP can occur at times that downstream periphyton growth downstream may be stimulated.

With respect to nutrient speciation, internally-driven reservoir nutrient dynamics due to stratification patterns and hydraulic residence time in Iron Gate and Copco 1 Reservoirs appear to influence ortho-phosphorus and, to a lesser degree, ammonium concentrations within the Hydroelectric Reach. Soluble reactive phosphorus (surrogate measure for orthophosphate) concentrations in the riverine portions of the Hydroelectric Reach generally follow a decreasing longitudinal trend through this reach for summer and fall months (i.e., May through November; see Figure C-12); however, concentrations in Iron Gate Reservoir can exceed those of upstream sites (i.e., Klamath River downstream of Keno Impoundment, Copco 1 Reservoir) particularly between September and November (Asarian et al. 2009, et al. 2010; Raymond 2009, 2010). Concentrations of orthophosphate are generally constant throughout the water column in winter months when the reservoirs are mixed, while in stratified periods (i.e., May–October/November) vertical concentration gradients develop in Copco 1 and Iron Gate Reservoirs (Raymond 2008, 2009, 2010). For example, concentrations near the bottom of Copco 1 Reservoir reached 1.4 mg/L in September and October of 2008 and 2009, while in Iron Gate Reservoir they remained below 0.5 mg/L throughout the water column.

Data from 2001–2008 indicate that nitrate concentrations often peak in the vicinity of J.C. Boyle Reservoir and decrease through the remainder of the Hydroelectric Reach (Raymond 2009). On a seasonal basis, coupled nutrient and algal data indicate that nitrate levels decrease during phytoplankton blooms in the Hydroelectric Reach; cyanobacteria blooms were recorded in Iron Gate and Copco 1 Reservoirs in summer and fall 2005 coincident with a nitrate decrease of up to 0.8 mg/L between the inflow to Copco 1 and the outflow of Iron Gate Reservoirs (Kann and Asarian 2007). Dilution from the springs downstream of J.C. Boyle Dam also reduces nitrate concentrations in this reach.

Relatively high levels of ammonia have been recorded in the Hydroelectric Reach. While available data collected to date suggests no actual ammonia toxicity events associated with the operation of the Four Facilities (NCRWQCB 2010), elevated ammonia levels in the deeper portions of the hypolimnion of both Copco 1 and Iron Gate Reservoirs in summer of 2005 exceeded 0.6 mg/L (Figures 12 and 14 in Kann and Asarian 2007), indicating that anoxic conditions are likely causing conversion of organic nitrogen in reservoir deposits to ammonia and introducing the potential for episodic in-reservoir toxicity events depending upon reservoir mixing conditions. From 2001 to 2004, June and November mean ammonia concentrations in Iron Gate Reservoir were 0.1–0.2 mg/L to a depth of 45 meters, whereas Copco 1 Reservoir concentrations were consistently higher for the 20–32 meter depth and were 0.9–1.0 mg/L in September and October (FERC 2007). Only minor increases in ammonia (0.05−0.1 mg/L) have been observed to occur in Copco 1 and Iron Gate Reservoirs, most often during October and November (Kann and Asarian 2005, 2007).

C.3.2 Lower Klamath Basin

C.3.2.1 Iron Gate Dam to Salmon River

Historical (1950–2001) TP data indicate median values of 0.11–0.19 mg/L in the Lower Klamath Basin between Iron Gate Dam and Seiad Valley, with the highest values occurring just downstream of the dam (Figure C-11). Variability over the long-term record in this reach is lower than upstream reaches, with concentrations varying from near zero to over 0.3 mg/L for the period of record (Figure C-11). The historical record indicates relatively low variability in orthophosphate concentrations in the reach (as compared with variability in the Upper Klamath Basin), with median values of 0.03–0.1 mg/L (PacifiCorp 2004b).

More recent data indicate that phosphorus dynamics in the Klamath River immediately downstream of Iron Gate Dam are affected by conditions within the Project reservoirs (Section C.3.1.4). During May 2005–November 2008, peak TP concentrations at locations downstream of Iron Gate Dam tended to occur between mid-August and early October, which is roughly 1 to 2 months later than peak timing in upstream reaches and may be due to the hydraulic residence time in Iron Gate and Copco Reservoirs or release of TP from anoxic sediments during summer stratification, or following algal bloom and death (Figure C-12). Highest TP concentrations were approximately 0.25 mg/L downstream of Iron Gate Dam in 2007 and 2008, with a steep late-fall decline in TP in some years and a more gradual decline in others (Figure C-12). Orthophosphate tends to decrease in the mainstem Klamath River with distance downstream of Iron Gate Dam (FERC 2007, Asarian et al. 2010). Seasonal trends in orthophosphate closely follow observed TP concentrations and for the period 2005–2008 this phosphorus species regularly accounts for 60 to 90 percent of TP sampled (Asarian et al. 2010).

For the period 1996–2007, average TN concentrations downstream of Iron Gate Dam (RM 190.1), vary by year, with mean concentrations of 1.2 mg/L (FERC 2007) and a range of measured concentrations from <0.1 to over 2.0 mg/L (NCRWQCB 2010). Additional historical (1951–2001) nitrogen data is available as TKN (a measure of organic nitrogen plus ammonia). TKN median values for this period were 0.6–0.9 mg/L in the Lower Klamath Basin between Iron Gate Dam and Seiad Valley, with the highest median values occurring just downstream of the dam (PacifiCorp 2004b). Variability over the long-term record in this reach is relatively low compared with that of upstream reaches. For 1951–2001, high variability in nitrate concentrations is apparent in the reach between Iron Gate Dam and the Salmon River confluence, with some relatively high concentrations (>5 mg/L) occurring at the Seiad Valley location (RM 129.4) (PacifiCorp 2004b).

More recent data indicate that nitrogen dynamics in the Klamath River immediately downstream of Iron Gate Dam are also affected by conditions within the KHP reservoirs (Section C.3.1.4). Based on data collected May 2005–November 2008, TN concentrations in the river downstream of Iron Gate Dam are generally lower than those in upstream reaches (Figure C-13) due to dilution from the springs downstream of J.C.

Boyle Dam and reservoir retention in the Klamath Hydropower Reach (Asarian et al. 2009). Further decreases in TN occur in the mainstem river downstream of Iron Gate Dam due to a combination of tributary dilution and in-river nitrogen removal processes such as denitrification and/or storage related to biomass uptake (Asarian et al. 2010). On a seasonal basis, TN increases from May through November, with peak concentrations (1−1.5 mg/L) typically observed during September and October (Figure C-13). Previous analysis of the 2001−2004 dataset also indicated that median nutrient concentrations in the Klamath River from Iron Gate Dam to (RM 190.1) to Seiad Valley (RM 129.4) exceeded 0.2 mg/L (Asarian and Kann 2006b). Downstream of Seiad Valley, median TN concentrations were often at or only slightly greater than 0.2 mg/L TN (Asarian and Kann 2006b).

Ratios of TN to TP (TN:TP) measured in the Klamath River suggest that the system is generally N-limited with some periods of co-limitation by N and P; however, concentrations of both nutrients are high enough in the river from Iron Gate Dam (RM 190.1) to approximately Seiad Valley (RM 129.4) (and potentially further downstream) that nutrients are not likely to be limiting primary productivity (i.e., periphyton growth) in this portion of the Klamath River (FERC 2007, Hoopa Valley Tribal Environmental Protection Agency [HVTEPA] 2008, Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010). Since these species can fix their own nitrogen from the atmosphere, nitrogen would not limit their growth.

Based on data collected during 2005–2008, nitrate concentrations also tend to decrease longitudinally in the Klamath River downstream of Iron Gate Dam (Asarian et al. 2010). Although patterns in nutrient concentrations vary between years, nitrate typically increases during August and September, with measured concentrations downstream of Iron Gate Dam greater than 0.25 mg/L each year from 2005 through 2008 (Asarian et al. 2010). In the fall, nitrate concentrations tend to increase again, reaching values of over 0.6 mg/L (Asarian et al. 2010). Mean 2000–2004 nitrate concentrations downstream of Iron Gate Dam were 0.15–0.44 mg/L between March and November, with the highest concentrations observed in early September (FERC 2007). Over the same time period, mean nitrate concentrations farther downstream near the confluence of the Shasta River (RM 176.7) had decreased to 0.02–0.36 mg/L, with peaks observed in early November (FERC 2007). Nitrate generally comprises less than 40 percent of the TN concentration throughout the lower Klamath River (Asarian et al. 2010).

As a result of the seasonal production of ammonia in anoxic hypolimnetic waters of the Project reservoirs (Section C.3.1.4) and the high pH levels (>7.5 pH units) measured seasonally downstream of Iron Gate Dam (YTEP 2005; NCRWQCB 2006), the NCRWQCB evaluated all available sampling data records as part of Klamath River TMDL development. The NCRWQCB analysis showed that for sampling events in which all three parameters (pH, ammonia, and water temperature) were collected simultaneously, no acute or chronic toxicity exceedances of the North Coast Basin Plan criteria for ammonia were indicated (NCRWQCB 2010). For the May–November sampling period in 2005–2008, ammonia concentrations in the Klamath River downstream of Iron Gate Dam were generally <0.3 mg/L and constituted less than ten percent of the TN concentration (Asarian et al. 2010). Highest concentrations were measured during fall months downstream of Iron Gate Dam (RM 190.1), with late-fall ammonia concentrations generally increasing at this location and values increasing to above 0.2 mg/L during November 2006. For 2000−2004, mean ammonia levels of 0.13 mg/L were reported in Iron Gate Dam outflow (FERC 2007).

Although tributary dilution generally has a proportionally greater effect on nutrient concentration reductions in the Klamath River downstream of Iron Gate Dam, nutrient retention is an important component of overall nutrient dynamics in this reach. In a study of the June–October and July–September periods during 2005–2008, nutrient retention in the reach from Iron Gate Dam to the Klamath River Estuary was calculated after accounting for tributary dilution (Asarian et al. 2010). For the study, positive retention values represented seasonal removal of nutrients from the water column through storage in algae/plant biomass or denitrification, and negative retention represented an internal source of nutrients from sediment release or algal regeneration and nitrogen fixation. Retention rates downstream of Iron Gate Dam were variable but generally positive for TP, although negative retention was observed during some years in the reach between Seiad Valley (RM 129.4) and the Salmon River (RM 66), as well as further downstream to Turwar (RM 5.8) (Asarian et al. 2010). In general, TP and orthophosphate retention increased with distance downstream of Iron Gate Dam while particulate phosphorus retention decreased (or became more negative). Nutrient retention for TN was similarly positive, with instances of negative retention observed during 2005 between Iron Gate Dam (RM 190.1) and Seiad Valley (RM 129.4) (see Section C.3.2.2 for discussion of retention in lower reaches). Additionally, during 2005–2008, total inorganic nitrogen (TIN = nitrite + nitrate + ammonium) retention was consistently positive between Iron Gate Dam and as far downstream as the Trinity River confluence (RM 42.5). The Asarian et al. (2010) analysis indicates that large quantities of nitrogen and phosphorus were retained in the river across the roughly 130 miles from Iron Gate Dam to just downstream of the Salmon River at Orleans (RM 59.0): during July-September of 2007–2008, the incoming nutrient load at Iron Gate Dam was reduced by 24% for TP, 25% for ortho-phosphorus, 21% for particulate phosphorus, 41% for TN, 93% for TIN, and 21% for organic nitrogen.

C.3.2.2 Salmon River to Estuary

Downstream of the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River as compared with those measured farther upstream. Historical (1950–2001) TP data indicate median values of 0.06–0.07 mg/L in river between the Salmon River confluence and near the Klamath Estuary, with generally low variability (Figure C-11). Orthophosphate levels and variability over the long-term record in the reach downstream of the Salmon River are similar to those in the reach downstream of Iron Gate Dam (see previous section). Contemporary data (2005–2008) indicate that TP concentrations in this reach are generally 0.05–0.1 mg/L with peak values occurring in September and October. Downstream of the Trinity River, orthophosphate often accounts for less than 50 percent of TP, possibly due to dilution from the Trinity River (Asarian et al. 2010).

As with upstream reaches, historical (1951–2001) nitrogen data is available as TKN, nitrate, and ammonia. TKN median values downstream of the Salmon River for this period were 0.25–0.3 mg/L (PacifiCorp 2004b). Variability over the long-term record in this reach is dependent on sampling location, with the greatest variability for the most downstream site at Klamath Glen (RM 5). For 1951–2001, high variability in nitrate concentrations is apparent throughout this reach, with some relatively high concentrations (>3 mg/L) occurring at Orleans (RM 59) and Klamath Glen (RM 5) (PacifiCorp 2004b). Contemporary data indicate that on a seasonal basis, TN increases from May through November, with peak concentrations (<0.5 mg/L) typically observed during September and October (Figure C-13), which are at or above the Hoopa Valley Tribe numeric criterion of 0.2 mg/L TN (see Section 3.2, Table 3.2-6). Downstream of the Trinity River confluence (RM 42.5), TN concentrations are typically less than 0.5 mg/L (YTEP 2005), with general increases from spring to fall months. For the 2005–2008 dataset, TN increases were observed between September and October at Orleans (RM 59), upstream of the confluence with the Trinity River (≈RM 66), and at Turwar (RM 5) (Asarian et al. 2010) (Figure C-13).

Nutrient retention rates in the Klamath River from approximately the Salmon River confluence to the Trinity River are variable for the period 2005–2008, but generally positive for TN and TP. However, from the Trinity River to the Klamath River estuary, nutrient retention rates are generally negative (Asarian et al. 2010). For example, during 2005–2008, total inorganic nitrogen (TIN = nitrite + nitrate + ammonium) retention was consistently negative between the Trinity River confluence and Turwar (RM 5.8) (Asarian et al. 2010). The Asarian et al. (2010) analysis suggests that while nitrogen and phosphorus are largely being removed from the river upstream of the Trinity River confluence (RM 42.5) during the June–October and July–September study periods, downstream of the confluence, nutrients are being added.

C.3.2.3 Klamath Estuary

Nutrient levels in the Klamath River Estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, tidal prism, and location of the estuary mouth. In general, nutrient levels in the Klamath River Estuary are lower than in the Klamath River just upstream of the Trinity River confluence (RM 43.5) and comparable to the nearest river sampling station (RM 5) near Turwar (Sinnott 2007, 2008, 2009, 2010, 2011a). Inter-annual and seasonal variability are apparent in the contemporary data collected by the Yurok Tribe during 2006–2010 (Sinnott 2007, 2008, 2009, 2010, 2011a). For example, measured levels of TP in the Klamath River Estuary are below 0.12 mg/L during the period June–October 2006–2010. Contemporary data (2006–2010) indicate that TP concentrations in the Klamath River Estuary generally range from 0.020–0.100 mg/L with peak values generally occurring in September and October, although 2009 and 2010 data indicated that concentrations of TP can continue to increase into November and December, especially during elevated river flows (Sinnott 2007, 2008, 2009, 2010, 2011a). During peak concentrations, values often exceed the Hoopa Valley Tribe's standard of 0.035 mg/L TP (see Section 3.2, Table 3.2-6). During the same period, orthophosphate is consistently reported at less than 0.05 mg/L. Orthophosphate often accounts for more than 50% of TP from June through October.

Contemporary data (2006–2010) indicate that TN concentrations in the Klamath River Estuary were consistently below 0.7 mg/L, generally ranging from 0.1–0.5 mg/L (Sinnott 2007, 2008, 2009, 2010, 2011a). Concentrations increase from June to October with peak values occurring in September and October, although 2009 and 2010 data indicate that concentrations can continue to increase into November and December, especially during high river flows (Sinnott 2007, 2008, 2009, 2010, 2011a). During peak concentrations, values often exceed the Hoopa Valley Tribe's standard of 0.2 mg/L TN (see Section 3.2, Table 3.2-6). During June–October 2006-2010, measured values of nitrate plus nitrite in the Klamath River Estuary are near or below the reporting limit (0.01 mg/L), with concentrations generally ranging from 0.01 mg/L to 0.05 mg/L. Concentrations of nitrate plus nitrite in the Klamath River Estuary increase from June to October, with peak values during this period occurring in September and October. As with TN, recent data indicates that nitrate plus nitrite concentrations can continue to increase into November and December, especially during elevated river flows (Sinnott 2010, Sinnott 2011a). Measured values of ammonia in the Klamath River Estuary were low, with measurements consistently below 0.1 mg/L during the period June-October 2006-2010, generally ranging from 0.01 mg/L to 0.03 mg/L, with peak values generally occurring in September. Many ammonia samples from the Klamath River Estuary return values near or below the reporting limit of 0.01 mg/L (Sinnott 2007, 2008, 2009, 2010, 2011a). However, the Klamath River Estuary sampling site has more detectable concentrations of ammonia than any other sampling site within the Yurok Reservation. Nutrient retention has not been explicitly measured in the estuary, although measurements have been made just upstream of the estuary in the reach from the Trinity River confluence (RM 43.5) to Turwar (5.8).

C.4 Dissolved Oxygen

C.4.1 Upper Klamath Basin

C.4.1.1 Wood, Williamson, and Sprague Rivers

Limited dissolved oxygen data were collected in the Wood River in 1991, with reported values of 9.8−12.7 mg/L at headwaters and 8.9−10.8 mg/L at the mouth (Kann 1993). Historical dissolved oxygen data for the Williamson and Sprague rivers are not generally available. More recent data collected by ODEQ (2002) for the Sprague River indicates that dissolved oxygen concentrations in this tributary to Upper Klamath Lake undergo large daily cycles due to algal photosynthesis and respiration causing dissolved oxygen supersaturation (>10 mg/L) during the day and depressed (<7 mg/L) levels at night.

Critically low dissolved oxygen conditions occur during summer months in the Sprague River, where slower water column velocities and elevated water temperatures encourage excessive periphyton (i.e., benthic or attached algae) growth.

C.4.1.2 Upper Klamath Lake

Dissolved oxygen concentrations in Upper Klamath Lake range from less than 4 mg/L to greater than 10 mg/L and exhibit high seasonal and spatial variability. High nutrient loading is the primary cause of eutrophication and subsequent low dissolved oxygen levels in Upper Klamath Lake. Water quality data collected by the Klamath Tribes contains periods of weeks during the summer months when dissolved oxygen levels in the lake are continuously below the ODEQ criterion of 5.5 mg/L for support of warm water aquatic life (Kann 2010, Morace 2007). Low (0–4 mg/L) dissolved oxygen concentrations occur most frequently in August, the period of declining algal blooms in the lake and warm water temperatures (Morace 2007, ODEQ 2002, Walker 2001).

Intermittent thermal stratification in Upper Klamath Lake can isolate a near-bottom layer of water, within which high sediment oxygen demand (SOD) and decomposition of algal cells depletes oxygen and creates potentially unsuitable conditions for resident fish (e.g., suckers) (Wood 2001, Wood et al. 2006). In the upper water column, high concentrations of N-fixing algae increase dissolved oxygen concentrations during photosynthesis, often resulting in oxygen super-saturation (>10 mg/L) during the daytime. The resulting water column profiles of oxygen are extreme, with depletion in bottom waters and super-saturation in surface waters. This chemical structure is stressful for fish but is not maintained for long periods of time as thermal stability tends to develop and erode over the course of a day (Wood et al. 2006). Stronger, more extended thermal stratification can occur in the relatively deep trench along Eagle Ridge. This can cause longer-term dissolved oxygen depletion, decreasing dissolved oxygen concentrations in the northern part of Upper Klamath Lake for periods of weeks (Wood et al. 2006, et al. 2008).

C.4.1.3 Link River Dam to Klamath River upstream of J.C. Boyle Reservoir

Historical (1950–2001) dissolved oxygen data collected during daytime at various times during the year indicate median values of 4.2–9.2 mg/L in the Upper Klamath River between Link River Dam and J.C. Boyle Reservoir, with the lowest median values occurring from RM 236 to RM 238, which is downstream of the Klamath Straits Drain (RM 240.5), and from RM 245 to RM 248, which is downstream of Link River Dam (RM 253.7) (Figure C-16). Variability over the long-term record in this reach is high, with multiple outlying data points above and below the 95th percentile, indicating both supersaturated and hypoxic dissolved oxygen conditions (PacifiCorp 2004b); the latter not meeting the ODEQ criterion of 5.5 mg/L for support of warm water aquatic life.

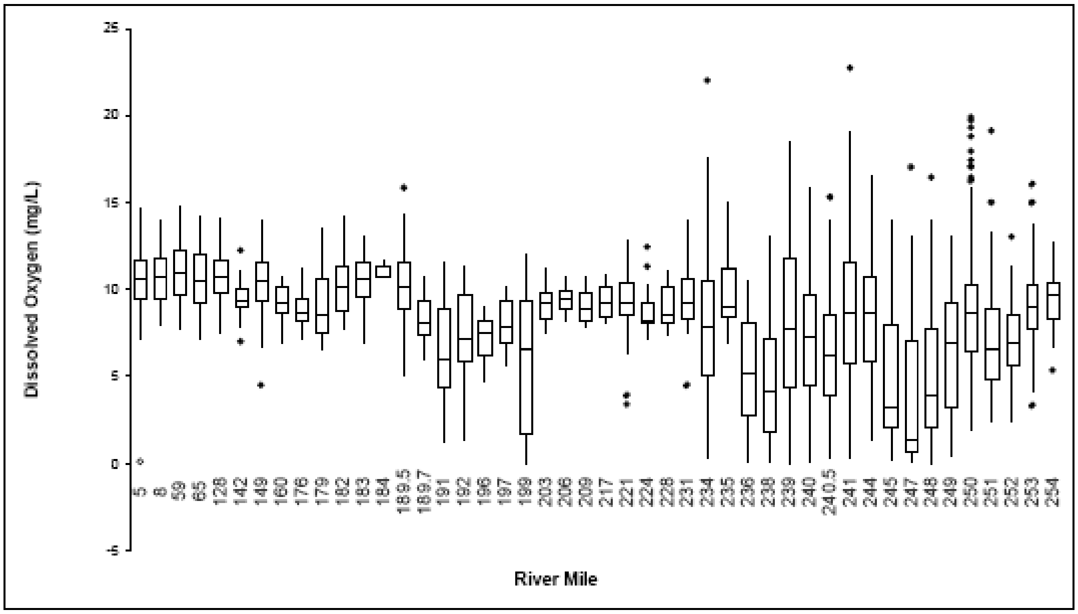


Figure C-16. Box and Whisker Plot of Historical Dissolved Oxygen Data Collected as Daytime Grab Samples from Various Sites in the Klamath River from Klamath River at Klamath Glen (RM 5) to Klamath River at Link River Dam (RM 254) between 1950 and 2001. Source: PacifiCorp 2004b.

More recent continuous *in-situ* data collected in June 2003 show dissolved oxygen concentrations below 4 mg/L and many instances where dissolved oxygen was below 1 mg/L in this reach (Doyle and Lynch 2005). In the downstream Keno Impoundment (including Lake Ewauna), dissolved oxygen reaches very low levels (< 1−2 mg/L) during July−October as algae transported from Upper Klamath Lake settle out of the water and decay (Sullivan et al. 2011) (see also chlorophyll-*a* discussion in Section C.6.1.3). Dissolved oxygen concentrations measured in 2005 from the downstream end of Lake Ewauna (RM 252) to Keno Dam (RM 235) ranged from 7 to 8 mg/L in the early spring, and by late July concentrations were less than 2 mg/L throughout the water column (Deas and Vaughn 2006). During this same period, dissolved oxygen concentrations in Link River inflow were 7–8 mg/L, but apparently had little effect on the dissolved oxygen concentrations in the Keno Impoundment (RM 252–233). Continuous dissolved oxygen data collected by Reclamation at Klamath River upstream of Keno Dam (USGS gage no. 11509370) for the period January 2006–December 2009 exhibit seasonally low dissolved oxygen from July through October (Figure C-17).

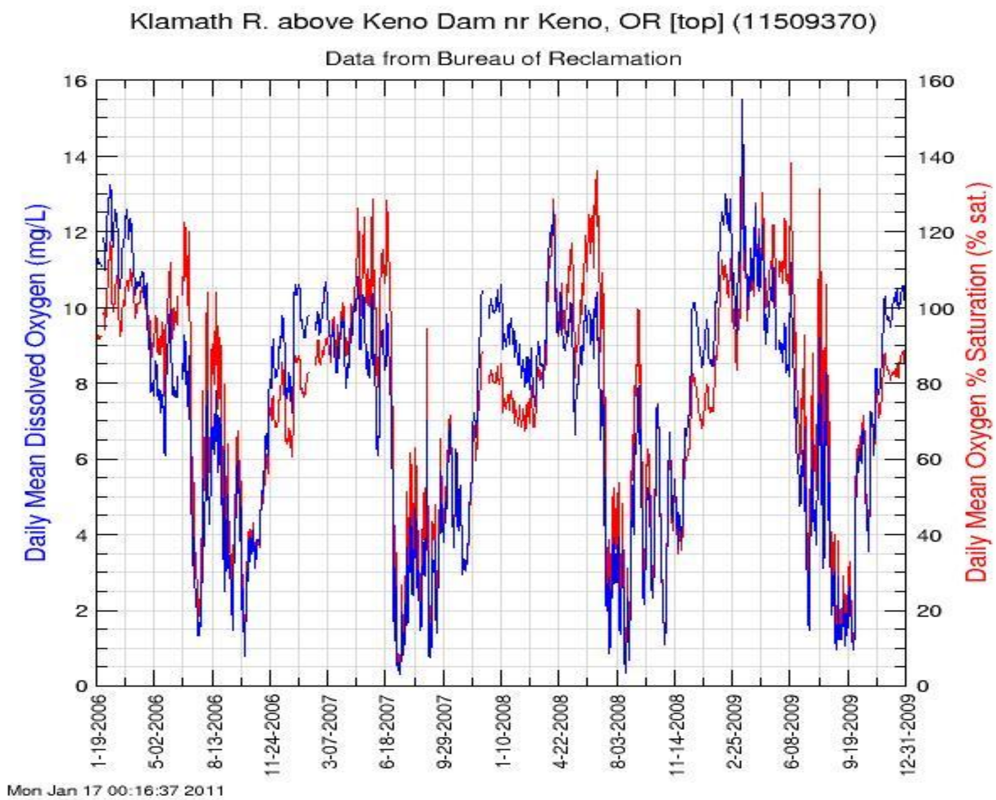


Figure C-17. Daily Mean Dissolved Oxygen Concentration and Percent Saturation for Continuous Data from Klamath River Upstream of Keno Dam, USGS Gage No. 1159370, from January 2006 to December 2009. Source: USGS Data Grapher 2010 (http://or.water.usgs.gov/cgi-bin/grapher).

In addition to water column dissolved oxygen measurements, *in-situ* SOD has been measured at multiple locations in the reach from Link River Dam to the Klamath River upstream of J.C. Boyle Reservoir. The SOD normalized to 20ºC (68ºF) (SOD_{20}) measured in June 2003 in Lake Ewauna (RM 253 to 247) and three sites downstream (Reclamation’s monitoring locations at ≈RM 246, at the location of the water intake for the North Canal, and at RM 244 and downstream of Klamath Straits Drain at RM 239) were 0.3–2.9 grams of oxygen per square meter per day (g O_2/m^2/day) (Doyle and Lynch 2005). Eilers and Raymond (2005) report higher summer SOD rates of 2.7–3.6 g O_2/m^2/day in Lake Ewauna, with the equivalent rate of water column oxygen demand due to SOD measured by Doyle and Lynch (2005) at an average of 0.75 mg/L/day (20ºC [68ºF]) and 0.012–1.87 mg/L/day (Sullivan et al. 2010). Following conversion from areal to volumetric units, the author’s report that measured water column oxygen demand is equal to or greater than oxygen demand in sediments. Accordingly, a reduction in the upstream load of particulate algal material (i.e., cyanobacteria) to this reach would decrease the high oxygen demand and may limit occurrences of anoxia and hypoxia in the water column (Sullivan et al. 2010, Doyle and Lynch 2005).

Historical water column oxygen demand data is also available for the reach from Link River Dam to the Klamath River upstream of J.C. Boyle Reservoir. The historical record indicates relatively high biological oxygen demand (BOD) (but also high variability) at the downstream end of Lake Ewauna (RM 247) (Figure C-18). Sullivan et al. (2010) measured BOD in the Klamath River between Keno Dam (RM 233) and Link River Dam (RM 253.7), as well as within Klamath Straits Drain (RM 240.5) from April to November 2007. They report the existence of at least two pools of organic matter (i.e., labile and refractory) in these reaches, each possessing a different average rate of decay. The labile pool of organic matter is dominated by particulate organic matter such as *A. flos-aquae* , and decays rapidly, with 80 percent of the associated oxygen demand expressed in 8 days (Sullivan et al. 2010). The refractory pool is also largely composed of particulate matter, but includes some dissolved organic matter and decays at a much slower rate, consuming oxygen for at least 60 days. Since the travel time from Link River to Keno Dam is 6–10 days during summer months, the majority of BOD in this reach during the summer months appears to be attributable to labile, algal-derived organic matter (Sullivan et al. 2010).

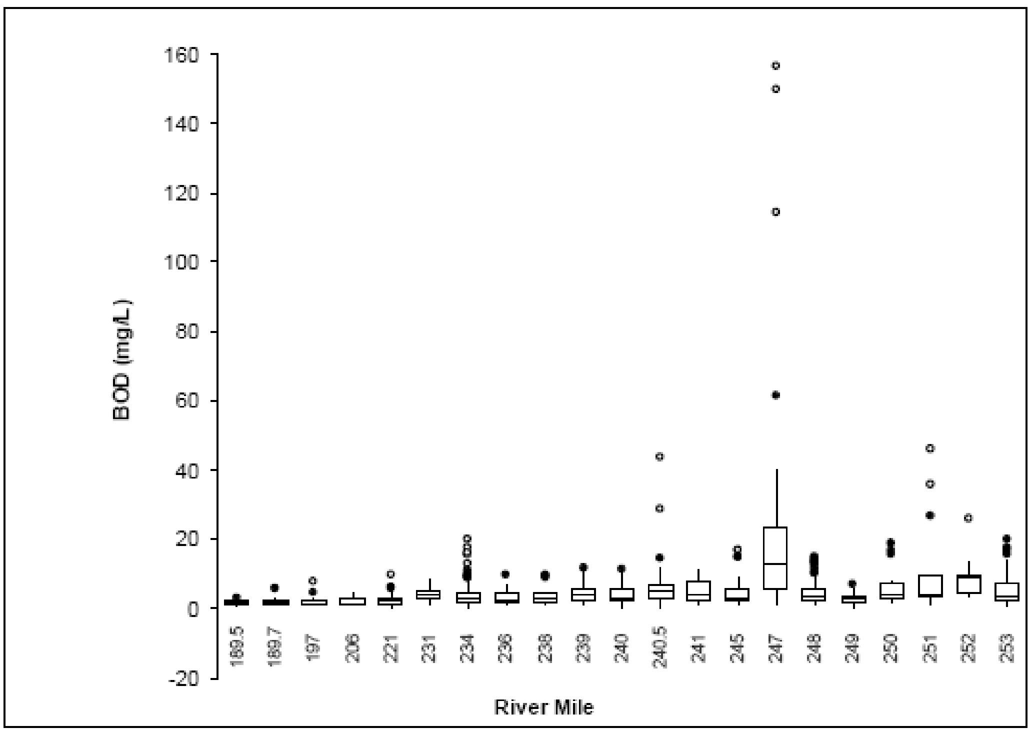


Figure C-18. Box and Whisker Plot of Historical BOD Data Collected from Riverine Sites in the Klamath River Between 1950 and 2001. Link River Dam (RM 253.7), Lake Ewauna and Keno Impoundment (RM 233–253.1), J.C. Boyle Reservoir (RM 224.7–RM 228.3), Copco 1 Reservoir (RM 198.6–203.1), Copco 2 Reservoir (RM 198.3–RM 198.6), Iron Gate Reservoir (RM 1901.1–196.9). Source: PacifiCorp 2004b.

Lastly, four facilities discharge treated wastewater to the Keno Impoundment; however, these facilities contribute a very small amount (<1.5% of the organic material loading) to the overall oxygen demand in the Keno Reach. Overall, decomposition of algae transported from Upper Klamath Lake appears to be the primary driver of low oxygen in the Keno Impoundment (including Lake Ewauna) (Sullivan et al. 2009, Kirk et al. 2010).

The Klamath River in Oregon from the California-Oregon state line to RM 251 is currently listed as impaired for dissolved oxygen under Section 303(d) of the CWA (see Section 3.2, Table 3.2-8). Oregon's Upper Klamath Lake Drainage TMDLs (2002) and Upper Klamath and Lost River draft TMDLs (2010) address dissolved oxygen, among other water quality parameters (see Section 3.2.2.4), and indicate that reductions in BOD loading from Upper Klamath Lake and both point and nonpoint sources in the Upper Klamath River are required in order to achieve water quality standards.

C.4.1.4 Hydroelectric Reach

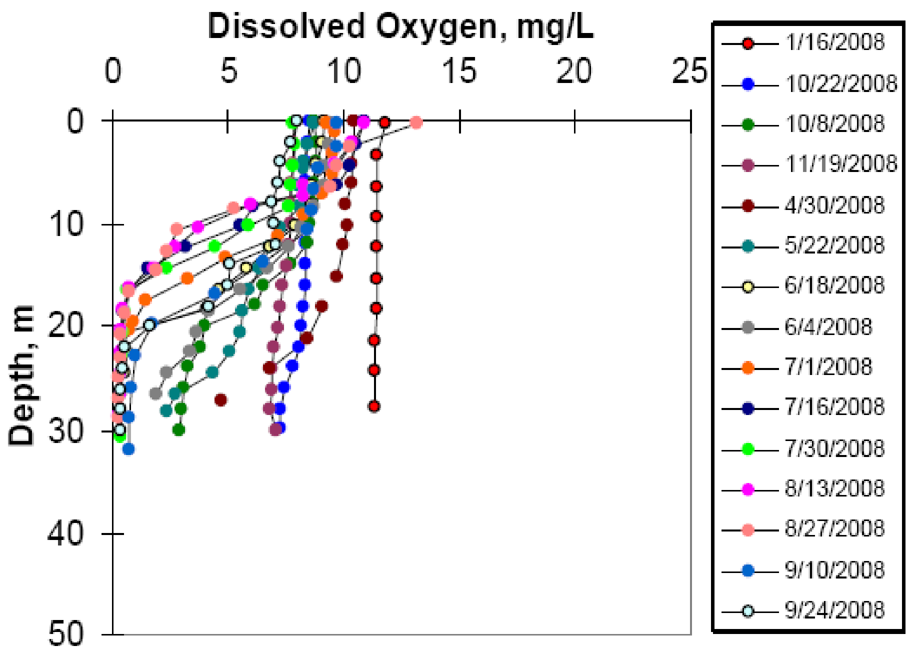
Dissolved oxygen levels in the Hydroelectric Reach vary on a seasonal and daily basis (e.g., Karuk Tribe of California 2002, 2003; FERC 2007; PacifiCorp 2004b, 2008a; USFWS 2008; FISHPRO 2000, Zedonis and Turner 2010). During summer, the KHP reservoirs exhibit varying degrees of supersaturation in surface waters due to high rates of algal photosynthesis and hypolimnetic anoxia as dissolved oxygen is depleted in bottom waters during seasonal thermal stratification and microbial decomposition of dead algae. J.C. Boyle Reservoir, a relatively long, shallow reservoir, does not stratify. However, J.C. Boyle Reservoir can exhibit large variations in dissolved oxygen due to conditions in the upstream reach from Link River Dam through the Keno Impoundment (including Lake Ewauna), and in Upper Klamath Lake (see previous section). Copco 1 and Iron Gate Reservoirs thermally stratify beginning in April/May and do not mix again until October/November (FERC 2007). Stratification occurs, with dissolved oxygen in Iron Gate and Copco 1 surface waters generally at or, in some cases above[2], saturation and levels in hypolimnetic waters reaching minimum values near 0 mg/L by July (for example, 2008 data shown in Figure C-19).

C.4.2 Lower Klamath Basin

C.4.2.1 Iron Gate Dam to Salmon River

Historical (1950–2001) dissolved oxygen data (reflecting day time grab sampling) are variable. Median values were 8.1–10.8 mg/L in the Klamath River between Iron Gate Dam and the confluence with the Salmon River, with the lowest median values and the greatest general variability in the first mile downstream of the dam (Figure C-16, PacifiCorp 2004b). Based on more recent data, dissolved oxygen concentrations immediately downstream of Iron Gate Dam regularly fall below 8 mg/L, the former North Coast Basin Plan water quality objective for dissolved oxygen during summer months (Karuk Tribe of California 2001, 2002, 2007, 2009; NCRWQCB 2010). Based

[2] At high rates of photosynthesis, oxygen production may exceed the diffusion of oxygen out of the water column and oxygen supersaturation may result.



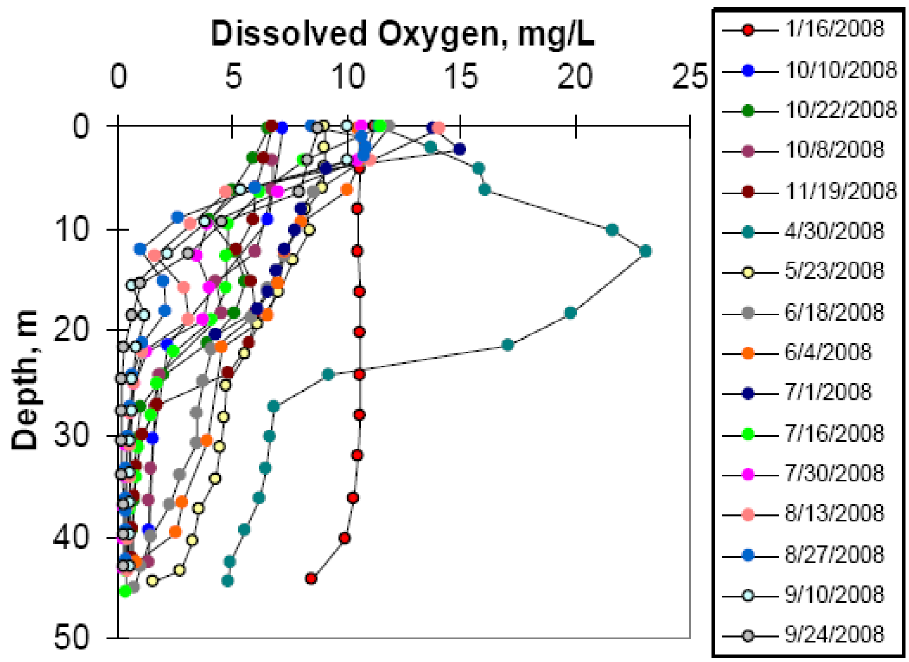


Figure C-19. Vertical Profiles of Dissolved Oxygen Concentration Measured in Copco 1 Reservoir Near the Dam (Top Plot) and Iron Gate Reservoir Near the Dam (Bottom Plot) in 2008. Source: Raymond 2009.

on continuous Sonde data collected at multiple locations in the lower Klamath River during summer 2004–2006, roughly 45 to 65 percent of measurements immediately downstream of Iron Gate Dam did not achieve the (previous) North Coast Basin Plan water quality objective of 8 mg/L (the objective is now based on percent saturation, see Section 3.2, Table 3.2-5). The percent of dissolved oxygen measurements below 8 mg/L decreases with distance downstream, particularly in 2005 and 2006. Table C-2 summarizes dissolved oxygen concentrations in the Lower Klamath River during Summer 2004-2006.

Table C-2. Dissolved Oxygen Concentrations in the Lower Klamath River during Summer 2004–2006.

Location	2004		2005		2006	
	n [1]	%	n [1]	%	n [1]	%
At Iron Gate Dam (RM 190.1)	2,706	64	4,498	45	5,391	61
Upstream of Shasta River (RM 176.7)	5,478	50	5,533	49	-	-
Upstream of Scott River (RM 143)	2,966	58	4,457	47	-	-
Seiad Valley (RM 129.4)	3,381	57	4,713	45	5,526	40
Orleans (RM 59)	57	37	4,533	23	5,349	15
Weitchpec (RM 43.5)	4,142	48	5,400	7	5,332	6
Downstream of Weitchpec (≈ RM 42)	5,500	16	3,529	11	5,293	4
Upstream of Trinity (RM 40)	-	-	5,535	5	5,739	3
Turwar (RM 5.8)	5,066	30	5,543	6	-	-

Source: Ward and Armstrong 2006, NCRWQCB 2010.

[1] Dissolved oxygen measurements were collected at 30-minute increments for a total of forty-eight daily measurements.

Key:

n=number of measurements

%=percent of measurements not achieving the North Coast Basin Plan previous water quality objective of 8 mg/L

Withdrawals occur at depths of approximately 12 meters in Iron Gate Reservoir, and thus downstream dissolved oxygen concentrations tend to reflect oxygen conditions in the lower epilimnion (Section C.4.1.4) when the reservoirs are stratified, with some increases in dissolved oxygen as the water is re-aerated upon discharge. In the fall, before and after reservoir turnover, low dissolved oxygen concentrations from the hypolimnion can be translated downstream. Table C-3 summarizes dissolved oxygen concentrations taken downstream of Iron Gate Dam (RM 190), representing the range of daily average measurements.

Table C-3. Range of Observed Dissolved Oxygen Concentrations Downstream of Iron Gate Reservoir.

Year	General Range of Daily Average Dissolved Oxygen (mg/L) downstream of Iron Gate Dam (RM 190, near USGS Gage No. 11516530)		
	September–October	November	Source
2001	4–6[(1)]	7–8	Karuk Tribe of California 2003
2002	4–9[(2)]	-	Karuk Tribe of California 2003
2004	6–9.5	8–9	Zedonis and Turner 2010
2006	6.5–8	7–8	Karuk Tribe of California 2009
2007	7–9[(2)]	-	Karuk Tribe of California 2009
2008	6.5–8.5	-	Karuk Tribe of California 2009
2009	7–10	-	Karuk Tribe of California 2010
2010	7–10.5	5–7	Preliminary data from PacifiCorp and Karuk Tribe of California, K. Fetcho, Yurok Tribe, pers. comm.

[1] No September data reported
[2] No October data reported

In situ continuous data collected during 2008–2010 by PacifiCorp in the Klamath River downstream of Iron Gate Dam demonstrates the seasonal decreases in dissolved oxygen (measured as percent saturation and concentration) originating from the reservoirs, with the lowest average monthly values occurring in October and November rather than during the months with the warmest water temperatures (i.e., July and August) (Table C-4).

It has been suggested that daily fluctuations of up to 1–2mg/L measured in the Klamath River downstream of Iron Gate Dam (RM 190.1) (Karuk Tribe of California 2002, 2003; YTEP 2005; NCRWQCB 2010) are caused by daytime algal photosynthesis and nighttime bacterial respiration. Low DO can also be often driven by bacterial decomposition of algae in the reservoir (Ward and Armstrong 2010).

Testing of turbine venting at Iron Gate Dam is has been conducted as part of Klamath Hydroelectric Settlement Agreement Interim Measures (Section 1.2.4 Klamath Hydroelectric Settlement Agreement, Interim Measures). Turbine venting is Interim Measure 3 (IM 3), and has a goal of improving dissolved oxygen concentrations downstream of Iron Gate Dam. Test results from 2008 indicate that dissolved oxygen levels immediately downstream of Iron Gate Dam can be increased through the mechanical introduction of oxygen as water passes through the turbines (Carlson and Foster 2008, PacifiCorp 2008a). Monitoring data taken during the tests suggest that an increase of approximately 0.5 to 2 mg/L in dissolved oxygen (approximately 7 to 20 percent saturation) is possible; however, further testing and monitoring are recommended (PacifiCorp 2008a).

Table C-4. Average Monthly Water Temperature, Dissolved Oxygen Percent Saturation, and Dissolved Oxygen Concentration in the Klamath River Downstream of Iron Gate Dam (RM 189.7).

Month	Average Monthly Water Temperature (°C)	Average Monthly Dissolved Oxygen (% Saturation)	Average Monthly Dissolved Oxygen (mg/L)
2008			
June	18.4	92.2	8.7
July	22.3	90.0	7.8
August	21.8	91.8	8.0
September	18.6	84.5	7.9
October	14.8	66.2	6.7
November	10.3	67.4	7.5
December	7.0	70.0	8.5
2009			
January	3.7	79.4	10.5
February	4.4	83.0	10.8
March	6.7	83.2	10.2
April	8.4	82.2	9.6
May	17.4	94.4	9.0
June	19.3	87.9	8.1
July	21.2	86.8	7.7
August	21.7	99.9	8.8
September	19.4	95.7	8.8
October	14.6	77.7	7.9
November	9.9	71.2	8.1
December	5.0	81.2	10.4
2010 (Preliminary)			
January	3.9	86.6	11.4
February	5.4	92.2	11.1
March	7.2	88.9	10.5
April	9.5	100.2	11.4
May	12.7	96.4	10.2
June	16.8	87.3	8.5
July	21.3	90.9	8.1
August	21.9	88.3	7.7
September	18.4	96.7	9.1
October	15.5	85.1	8.5
November	11.8	57.5	6.2

Raw daily data from http://www.pacificorp.com/es/hydro/hl/kr.html# (PacifiCorp 2008b, 2009, 2010). Data obtained with YSI 6600 V2 or 6900 Multiprobe Datasondes (30-minute intervals).

Farther downstream in the mainstem Klamath River, near Seiad Valley (RM 129.4), dissolved oxygen concentrations tend to increase; however, values are often below 8 mg/L (i.e., 2001, 2002, 2006, and 2009, as reported in Karuk Tribe of California [2001, 2002, 2007, 2009]). Dissolved oxygen concentrations near Seiad Valley continue to exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) approximately 10.5 mg/L, from June through November, 2001–2002 and 2006–2009.

C.4.2.2 Salmon River to Estuary

Measured concentrations of dissolved oxygen in the mainstem Klamath River downstream of the confluence with the Salmon River (RM 66) continue to increase relative to concentrations at upstream sites. Despite this, values sometimes fall below 8 mg/L in this reach (e.g., at the Orleans gage [RM 59] during 2001, 2002, 2006 as reported in Karuk Tribe of California [2001, 2002, 2007, 2009], Ward and Armstrong 2006, NCRWQCB 2010). Dissolved oxygen concentrations near Orleans also exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) 11.5 mg/L from June through November, 2001–2002 and 2006–2009. Extremely high mean daily dissolved oxygen concentrations (11–15.5 mg/L) (Sonde data) were reported for October 2006 at the Orleans gage (Karuk Tribe of California 2007, 2009).

Dissolved oxygen concentrations in the mainstem Klamath River upstream of the confluence with the Trinity River (RM 42.5) ranged 5.5–10.3 mg/L in September and October 2004, respectively, with minimum dissolved oxygen concentrations below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) for extended periods of time from mid-August through early September (YTEP 2005). In 2009 at this location, dissolved oxygen concentrations ranged 7.1–11.8 mg/L, with minimum dissolved oxygen concentrations dropping below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) for an extended period of time from mid-July to early August, and again from late August to early September (Sinnott 2010). In 2010, concentrations ranged 7.9–12.1 mg/L (Sinnott 2011b), with minimum dissolved oxygen concentrations remaining above 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (e.g., 7.0, 6.9, and 7.8 mg/L for July, August, and September, respectively, see Section 3.2, Table 3.2-5).

Further downstream, at the confluence with the Trinity River (RM 42.5) and at the Turwar gage (RM 5.8), daily minimum dissolved oxygen values at the Trinity River and Turwar sites during May through November are consistently observed to occur late-night or early in the morning, likely due to respiration by aquatic vegetation (YTEP 2005, Sinnott 2010, 2011b). At Turwar (RM 5.8) in 2004, minimum dissolved oxygen concentrations dropped below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) between late July and late August (YTEP 2005); dissolved oxygen concentrations ranging 5.9–10.1 mg/L were observed in August and September). In 2009, dissolved oxygen concentrations at Turwar ranged 7.3–11.7 mg/L, with minimum dissolved oxygen concentrations dropping below 8 mg/L for an extended period of time from mid-July to early August (Sinnott 2010). In 2010, concentrations ranged 7.8–11.8 mg/L, with minimum values remaining above 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (e.g., 7.0, 6.9, and 7.8 mg/L for July, August, and September, respectively, see Section 3.2, Table 3.2-5).

C.4.2.3 Klamath Estuary

Dissolved oxygen concentrations within the Klamath River Estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, vertical water column stratification (thermal and/or chemical), and location of the estuary mouth, the latter changing due to periodic sand bar movement. Dissolved oxygen concentrations have been monitored in the Klamath River Estuary by CDFG (Wallace 1998) and most recently by the Yurok Tribe Fisheries (Hiner 2006) and Environmental Programs (YTEP 2005) with support from the North Coast Regional Water Quality Control Board. Concentrations in the deeper, main channel of the estuary are generally greater than 6 to 7 mg/L throughout the year (Hiner 2006, YTEP 2005).

Lower dissolved oxygen concentrations ranging 2.5–5.5 mg/L have been measured near the bottom of deep pools or in heavily vegetated side channels (Wallace 1998). Low dissolved oxygen concentrations (<1 to 5 mg/L) have been observed during summer months in the relatively shallow, heavily vegetated south slough (Hiner 2006, Wallace 1998). The low levels of dissolved oxygen observed in the slough are likely due to high rates of growth and subsequent decomposition of algae and macrophytes, which are not abundant elsewhere in the estuary.

Dissolved oxygen becomes progressively more variable and generally lower in concentration nearer the estuary bottom and the estuary mouth, with concentrations frequently below 6 mg/L during summer months (Hiner 2006, YTEP 2005). Low dissolved oxygen has also been observed during late summer months when a sand berm forms across the river mouth, forcing the river to flow south diagonally between two sand spits. This berm prevents ocean water from entering the estuary, creating ‘lagoon-like’ conditions until higher flows breech the berm (Wallace 1998, Hiner 2006). These conditions were documented in 1994 and 2001; in 2001, a decrease in dissolved oxygen concentrations was measured related to sand berm formation, with especially marked decreases in dissolved oxygen in the south slough (Hiner 2006).

C.5 pH

C.5.1 Upper Klamath Basin

C.5.1.1 Wood, Williamson, and Sprague Rivers

The Sprague River is listed as impaired under Section 303(d) of the CWA for pH in the summer months based upon the 6.5–9.0 range established by ODEQ in the Upper Klamath Lake Drainage TMDLs (see Section 3.2, Table 3.2-8). In the Wood River subbasin, Campbell and Ehinger (1993) report pH levels of 6.9–8.2 in the headwaters and

7.4–8.2 at the mouth. During the summer months, Wood River has little potential to influence the overall pH of downstream Agency Lake, based upon low relative flow volumes. High pH levels (8.5–9.5) have been observed in the Sprague River linked primarily to high rates of periphytic (i.e., benthic or attached algae) algal photosynthesis (ODEQ 2002). The pH criterion (see Section 3.2, Table 3.2-8) has been exceeded on the mainstem Sprague River during the warmest part of the day in August from RM 79.1 to the confluence with the Williamson River.

C.5.1.2 Upper Klamath Lake

Upper Klamath Lake is listed as impaired under Section 303(d) of the CWA for pH based upon the 6.5–9.0 range established in the Upper Klamath Lake Drainage TMDLs (see Section 3.2, Table 3.2-8). During November–April (non-growing season) pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources 2005). However, in summer, instances of pH levels above 10 and extended periods of pH greater than 9 lasting for several weeks have been associated with large summer algal blooms occurring in the lake (Kann 2010; Morace 2007; Kann and Smith 1999). On a daily basis, algal photosynthesis can elevate pH levels during the day, with changes exceeding 2 pH units over a 24-hour period. Elevated pH is linked to nutrient dynamics in the lake, as increases in pH also increase phosphorus flux from internal loading via in-lake sediments to the water column by solubilizing iron-bound phosphorus. A threshold of pH 9.3 has been identified in the lake where the probability of internal phosphorus loading from lakebed sediments sharply increases (Kann and Walker 1999). A positive feedback loop can be created where an initially high phosphorus concentration supports an algal bloom, which then raises pH through photosynthesis and causes the release of phosphorus from lake sediments (Kann and Walker 1999). Estimates of internal loading of phosphorus range from 57% (Miller and Tash 1967) to 61% (Kann and Walker 1999) of the total phosphorus sources, with much of the internal loading source occurring in the summer. Internal loading in an unstratified lake such as Upper Klamath Lake is driven by several mechanisms including 1) high pH resulting in dissolution of iron and aluminum complexed phosphorus, 2) anoxic conditions at sediment-water interface resulting in dissolution of iron-phosphorus complexes, 3) temperature driven microbial metabolism resulting in mineralization of organic phosphorus into dissolved phosphorus, 4) dissolved phosphorus released directly from algal cell in the sediment, wind-driven sediment re-suspension, 5) bioturbation from benthic invertebrates allowing migration phosphorus in deeper sediment to migrate upward, and 6) chemical diffusion from phosphorus concentration gradients in the sediments.

Open water areas in Upper Klamath Lake tend to have the highest measured pH, reaching levels above 10 (Gearhart et al. 1995), while nearshore areas may have relatively lower pH of due to the production of acidic humic substances associated with fringe wetlands and marshes there (Aquatic Scientific Resources 2005). However, an estimated 35,000 acres of marsh and wetlands directly adjacent to Upper Klamath Lake have been converted to pasture or agricultural fields (Gearhart et al. 1995), potentially reducing the buffering effect of the littoral marshes on lake pH level under current conditions.

C.5.1.3 Link River Dam to Klamath River upstream of J.C. Boyle Reservoir

The Klamath River from Link River Dam to upstream of J.C. Boyle Reservoir, inclusive of the Keno Impoundment (and Lake Ewauna), is also listed as impaired under Section 303(d) of the CWA for pH during the summer months (see Section 3.2, Table 3.2-8). Generally, pH in the reach from Link River Dam through the Keno Impoundment increases from spring to early summer and decreases in the fall; however, there are site-dependent variations in the observed trend. Measurements of pH collected by Sullivan et al. (2008) in the Keno Impoundment (≈RM 235 to RM 253) from April to November 2007 indicate pH ranging from 7.2 in April to a one-day peak of 9.9 in November (Sullivan et al. 2008). Downstream at Miller Island, pH was typically 8.5 in the spring, increasing to values at or near 9.5 in the summer, and decreasing to near 7.5 in the fall. In 2009, springtime pH levels at J.C. Boyle Reservoir were also typically 8.5, decreasing during the summer and fall to 7.6–7.9 (Watercourse Engineering, Inc. 2011).

C.5.1.4 Hydroelectric Reach

The Hydroelectric Reach is not listed as impaired under Section 303(d) of the CWA for pH (see Section 3.2, Table 3.2-8). Based upon monitoring conducted by PacifiCorp, pH in the Hydroelectric Reach is seasonally variable, with levels near neutral (7.5–8.0) during the winter and increasing in the spring and summer (7.7–8.1). Peak values (8–9.2) are recorded during May and September (Raymond 2010). Longitudinally, pH ranges from 7.3 to 9.2 in this reach, with the lowest values recorded downstream of J.C. Boyle Reservoir and the highest values in Copco and Iron Gate Reservoirs (Raymond 2008, 2009, 2010). The pH is typically elevated where and when algal photosynthesis rates are high; maximum values (e.g., between 8 and 9) are measured at or near the water surface during periods of thermal stratification and high nutrient concentrations (Raymond 2008).

C.5.2 Lower Klamath Basin

C.5.2.1 Iron Gate Dam to Salmon River

Although not listed as impaired for pH under Section 303(d) of the CWA (see Section 3.2, Table 3.2-8), the California North Coast Basin Plan pH maximum of 8.5 units is regularly exceeded in the lower Klamath River downstream of Iron Gate Dam (USFWS 2008; FERC 2007; FISHPRO 2000; Karuk Tribe of California 2002, 2003; YTEP 2005; NCRWQCB 2006, 2010). During April through October 2000–2004, incidences of pH *below* the minimum North Coast Basin Plan limit of 7.0 were also observed immediately downstream of Iron Gate Dam (RM 190.1) (PacifiCorp 2004b). Because the Klamath River is a weakly buffered system (i.e., has typically low alkalinity <100 mg/L; PacifiCorp [2004a], Karuk Tribe of California [2010]) it is susceptible to photosynthesis-driven daily swings in pH. Observed exceedances of pH water quality objectives usually occur during later afternoon or early evening, following the period of maximum photosynthesis (NCRWQCB 2010). In addition, the highest pH values generally occur during late-summer and early-fall months (August–September). In 2007, daily maximum pH values downstream of Iron Gate Dam (≈RM 189) were 8.2–9.6 with the highest documented pH occurring in September (Figure C-20); near Seiad (≈RM 128), maximum pH values were slightly lower, at 8.1–9.4 with the highest documented pH occurring in mid-August (and Figure C-21; Karuk Tribe of California 2007).

The most extreme pH exceedances typically occur from Iron Gate Dam (RM 190.1) to approximately Seiad Valley (RM 129.4), with pH values generally decreasing with distance downstream (Figure C-22; FERC 2007; Karuk Tribe of California 2007, 2009, 2010). However, during May–October 2005, the greatest number of pH exceedances in this reach occurred just upstream of the mainstem confluence with the Shasta River (RM 66) (Figure C-23).

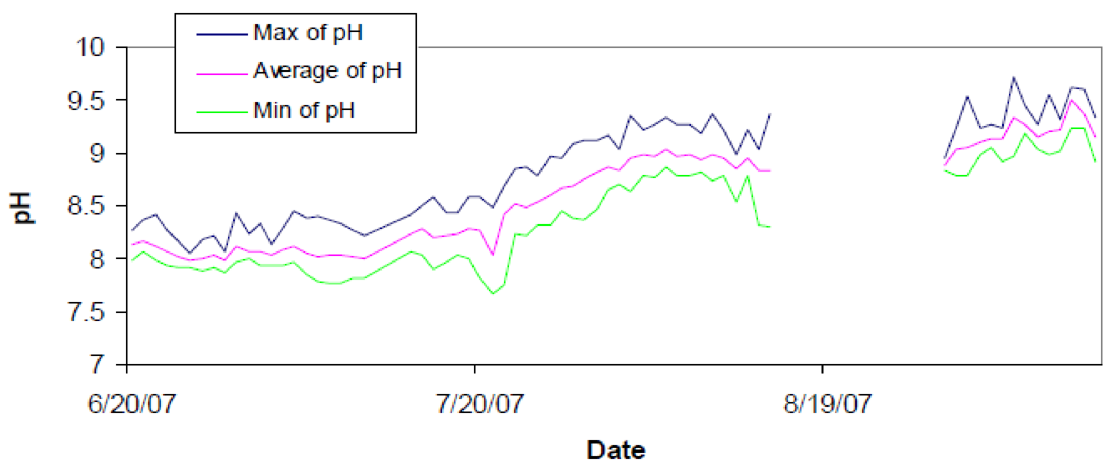


Figure C-20. Daily Maximum, Mean, and Minimum pH Values in the Klamath River Downstream of Iron Gate Dam (RM 190.1) from June to October 2007. Source: Karuk Tribe of California 2007.

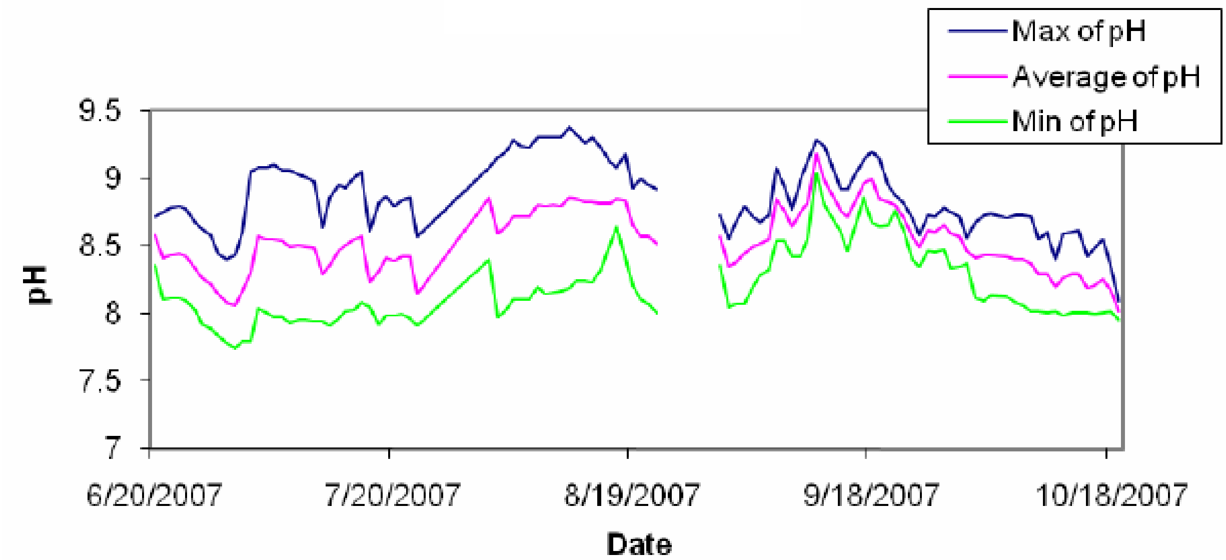


Figure C-21. Daily Maximum, Mean, and Minimum pH Values in the Klamath River near Seiad (≈RM 128) from June to October 2007. Source: Karuk Tribe of California 2007.

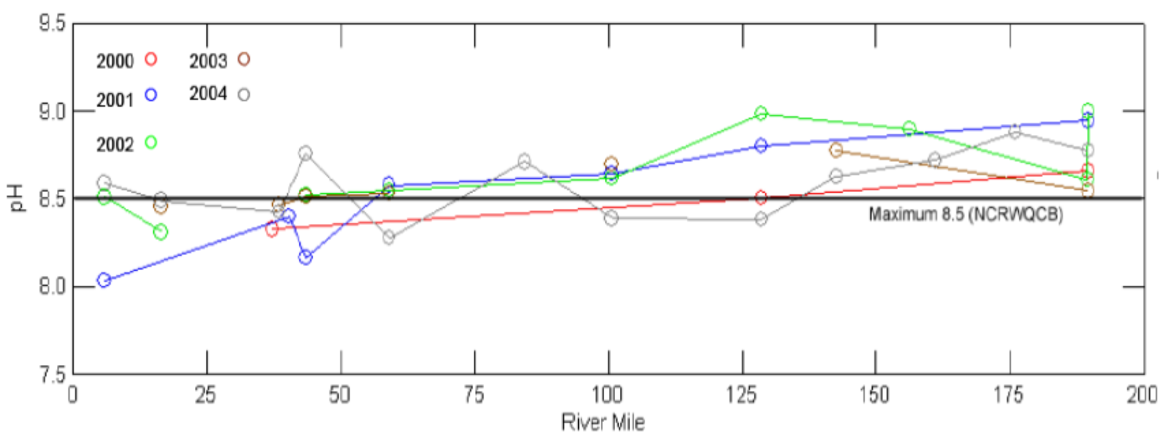


Figure C-22. Average August Daily Maximum pH Values for Locations along the Mainstem Klamath River Downstream of Iron Gate Dam for the Years 2000–2004 using Data Collected by USFWS, USGS, and the Karuk Tribe of California and Yurok Tribe. Source: Kier Associates 2006 as cited in FERC 2007.

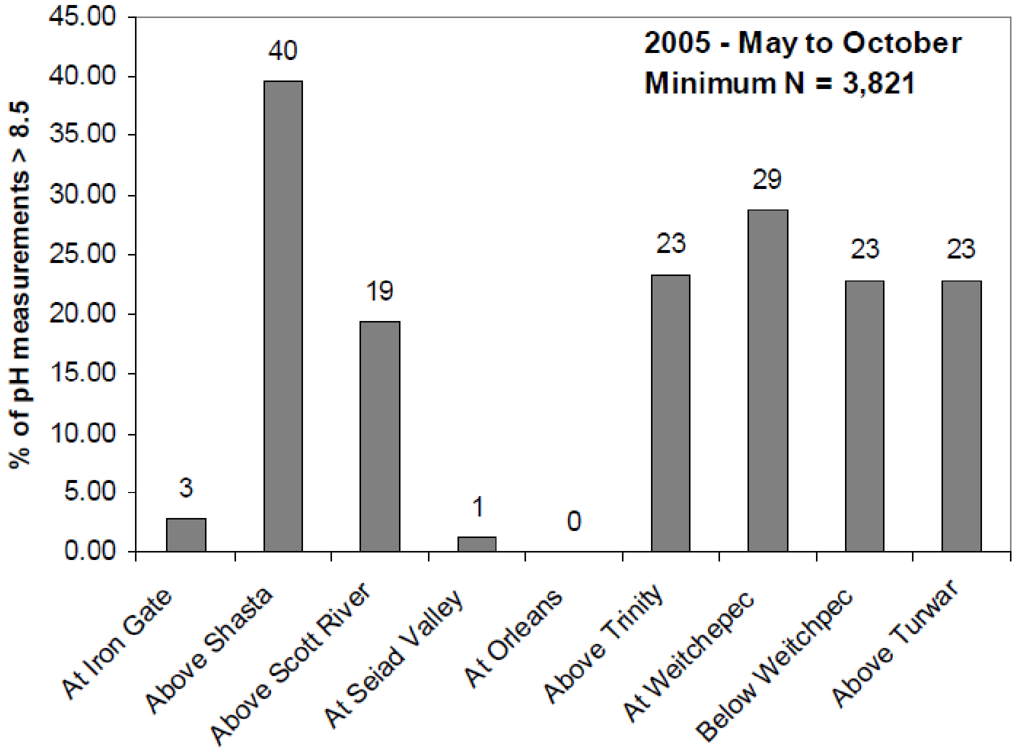


Figure C-23. Percent of pH Measurements in the Lower Klamath River Exceeding the North Coast Basin Plan Water Quality Objective of 8.5 pH Units during 2005. Source: NCRWQCB 2010

C.5.2.2 Salmon River to Estuary

The North Coast Basin Plan pH maximum of 8.5 is also regularly exceeded in the lower Klamath River between the Trinity River and Turwar Creek during summer months (Figure C-19; USFWS 2008; FISHPRO 2000; Karuk Tribe of California 2002, 2003; YTEP 2005; NCRWQCB 2006, 2010). Water quality monitoring by the Karuk Tribe includes pH data from Orleans (RM 59), which is just downstream of the mainstem confluence with the Salmon River (see also Section C.5.2.1). Daily maximum pH values at Orleans were 7.9– 8.9 from June through October 2007, with the highest pH occurring in mid-September (Figure C-24; Karuk Tribe of California 2007). In the mainstem river between the confluence with the Trinity River and the Klamath Estuary, annual water pH monitoring has been conducted by the YTEP since 2002 (YTEP 2004, YTEP 2005, Sinnott 2010). During 2009 monitoring, peak pH values were documented from July through September with the highest daily maximums recorded in early July; the highest pH values were documented at the most upstream location (i.e., just over 9.0 at Klamath River at Weitchpec [RM 43.5]) while both sample locations farther downstream were approximately 8.8 (Klamath River upstream of Tully Creek [RM 38.5] and upstream of Turwar Boat Ramp [RM 8]; Figure C-25; Sinnott 2010).

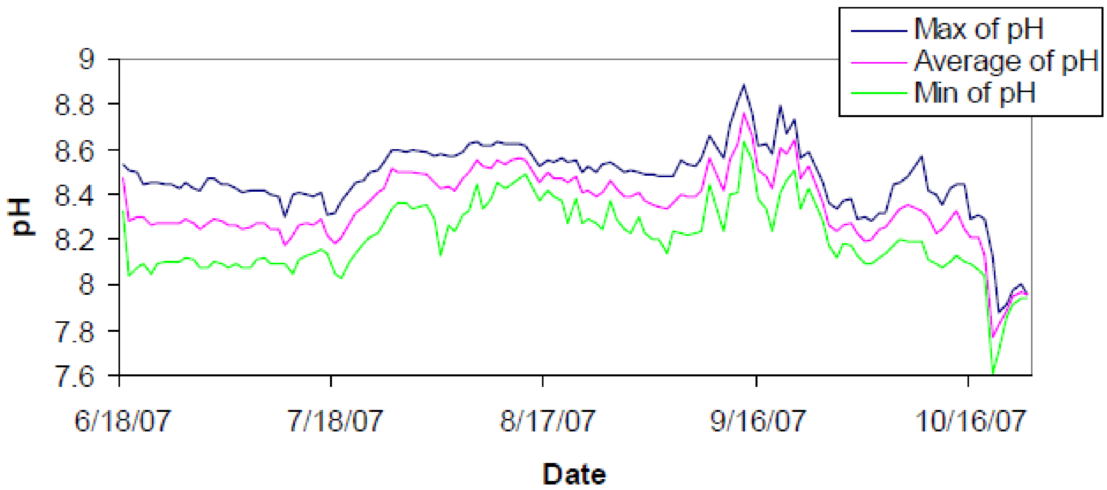


Figure C-24. Daily Maximum, Mean, and Minimum pH Values on the Klamath River near Orleans (RM 59) from June to October 2007. Source: Karuk Tribe of California 2007.

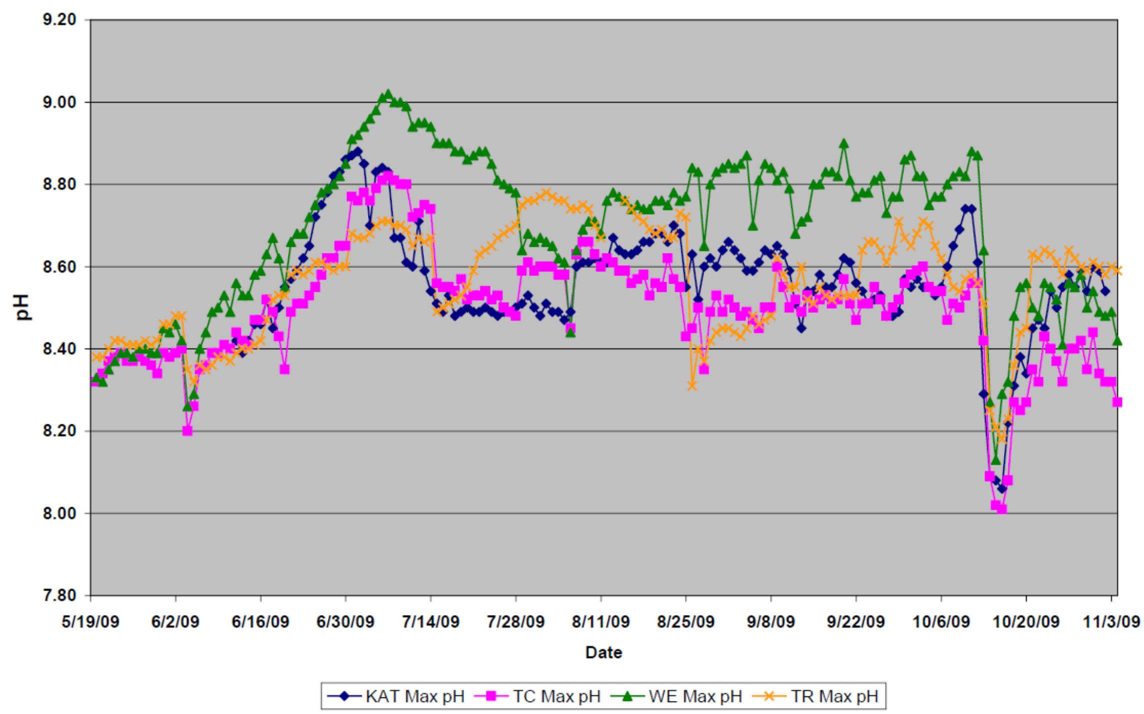


Figure C-25. Daily Maximum pH in the Klamath River at Weitchpec (RM 43.5 [WE]), Upstream of Tully Creek (RM 38.5 [TC]), and Upstream of Turwar Boat Ramp (RM 8 [KAT]), as well as in the Trinity River (RM 40 [TR]) near the Confluence with the Klamath River (RM 0.5 [TR]). Source Sinnott 2010.

C.5.2.3 Klamath Estuary

pH within the Klamath River Estuary is variable spatially and temporally and is influenced by season, river flow, vertical stratification (thermal and/or chemical), and location of the estuary mouth, the latter changing due to periodic sand bar movement. Although not listed as impaired for pH under Section 303(d) of the CWA (see Section 3.2, Table 3.2-8), the North Coast Basin Plan pH maximum of 8.5 is also regularly exceeded in the Klamath Estuary (Figure C-19) (YTEP 2005). Based on Yurok Tribe water quality data, pH in the Klamath Estuary ranges between approximately 7.5 and 9, with peak values generally occurring during the summer months (YTEP 2005, Sinnott 2010, Sinnott 2011b). Daily variations in pH are typically on the order of 0.5 pH units, and fluctuations tend to be somewhat larger in the late summer and early fall. The Environmental Fluid Dynamics Code estuary model component used in the California Klamath River TMDL development as well as observed data show very low algae and chlorophyll-*a* concentrations in the estuary (YTEP 2005), suggesting that local photosynthesis and biological respiration are not significant enough to cause large daily fluctuations of pH, as seen in upstream reaches. When large daily fluctuations are observed, they are likely caused by an upstream daily signal that is subsequently transported into the estuary.

C.6 Algal Toxins and Chlorophyll-a

C.6.1 Upper Klamath Basin

C.6.1.1 Wood, Williamson, and Sprague Rivers

M. aeruginosa occurrence has not been reported in the Wood, Williamson, and Sprague Rivers, and algal toxin data are not available for these rivers. Measured water column chlorophyll-*a* production in the Sprague River does not currently exceed action levels (see Section 3.2, Table 3.2-8) (ODEQ 2002), although data collected prior to 2000 is not readily available. Abundant periphytic algae (i.e., benthic or attached algae) are known to cause water quality impairments for dissolved oxygen and pH in these tributaries to Upper Klamath Lake (Sections C.4.1.2 and C.5.1.2). Chlorophyll-*a* concentrations in Wood River increase from the headwaters to the mouth; flowing water at the headwater springs of the Wood River exhibit a total chlorophyll-*a* concentration of 0–0.3 µg/L, while concentrations at the mouth range from 0.9 to 3.9 µg/L (Campbell et al. 1993).

C.6.1.2 Upper Klamath Lake

In Upper Klamath Lake, large summertime blooms of cyanobacteria are typically dominated by *A. flos-aquae* , with relatively smaller amounts of *M. aeruginosa* present (see Section 3.4, Algae). Despite this, *M. aeruginosa* is believed to be responsible for the production of microcystin in the lake. A preliminary study of the presence, concentration, and dynamics of microcystin in Upper Klamath Lake, particularly as related to Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) exposure, USGS collected water samples at multiple lake sites from July to October 2007 and June through September 2008. At most sites and on most sampling dates in 2008, microcystin concentrations were equal to or greater than the World Heath Organization (WHO) limit for drinking water (1 µg/L) and peaked at 17 µg/L, which is above the Oregon Department of Public Health guidelines for issuing public health advisories. Microcystin levels were generally lower in 2007 than 2008, but concentrations at some sites still reached a peak of 6 µg/L. Additional microcystin data collection in Upper Klamath Lake is ongoing (Vanderkooi et al. 2010).

Upper Klamath Lake and Agency Lake are listed as impaired under Section 303(d) of the CWA for chlorophyll-*a* (see Section 3.2, Table 3.2-8). The Klamath Tribes water quality monitoring data from 1990 through 2009 provide chlorophyll-*a* data for Upper Klamath Lake from June through September (Kann 2010). Chlorophyll-*a* concentration varies by location, as related to wind, temperature, pH and nutrients (Morace 2007). Chlorophyll-*a* concentrations measured in 2008 in the relatively sheltered Wocus Bay on the southwest side of the lake, show a series of peaks (1,154 µg/L in mid-July, 862 µg/L in early September) due to concentrated cyanobacteria blooms, whereas concentrations at the mid-lake monitoring station were considerably lower at 116 and 45 µg/L in mid-July and early September, respectively. A correlation between lake mean TP, chlorophyll-*a* and pH was developed by Walker (2001) to develop the TMDL for total phosphorus as the controlling parameter in addressing adverse pH and dissolved oxygen levels in Upper Klamath Lake. Walker (2001) reports a relationship between lake mean TP and chlorophyll-*a* (R^2=0.65) and between coincident measurements of chlorophyll-*a* and lake mean pH (R^2=0.87). Based on this relationship, measured values of pH >9 in Upper Klamath Lake are likely to coincide with chlorophyll-*a* concentrations of >50 µg/L.

C.6.1.3 Link River Dam to Klamath River upstream of J.C. Boyle Reservoir

Multiple years of data characterizing the occurrence of *M. aeruginosa* in the reach from Link River Dam to upstream of J.C. Boyle Reservoir have been collected by PacifiCorp and The Klamath Tribes (Kann 2006). Microcystin data have been collected in this reach only relatively recently (May–December 2009) with concentrations of 0.09–0.66 µg/L (Watercourse Engineering, Inc. 2011). Algal species occurrence is discussed further in Section 3.4, Algae.

The Klamath River from RM 231 to RM 251, including the Keno Impoundment, is listed as impaired under Section 303(d) of the CWA for chlorophyll-*a* (see Section 3.2, Table 3.2-8). Historical (1950–2001) chlorophyll-*a* data indicate median values of 2.8–37 µg/L in the Upper Klamath Basin between Link River Dam and J.C. Boyle Reservoir, with the highest median values occurring at RM 251 in the Keno Impoundment (including Lake Ewauna) (Figure C-26). Variability over the long-term record in this reach is high, with multiple outlying data points above and below the 95th percentile, indicating chlorophyll-*a* levels greater than 100 µg/L at multiple sites in the reach.

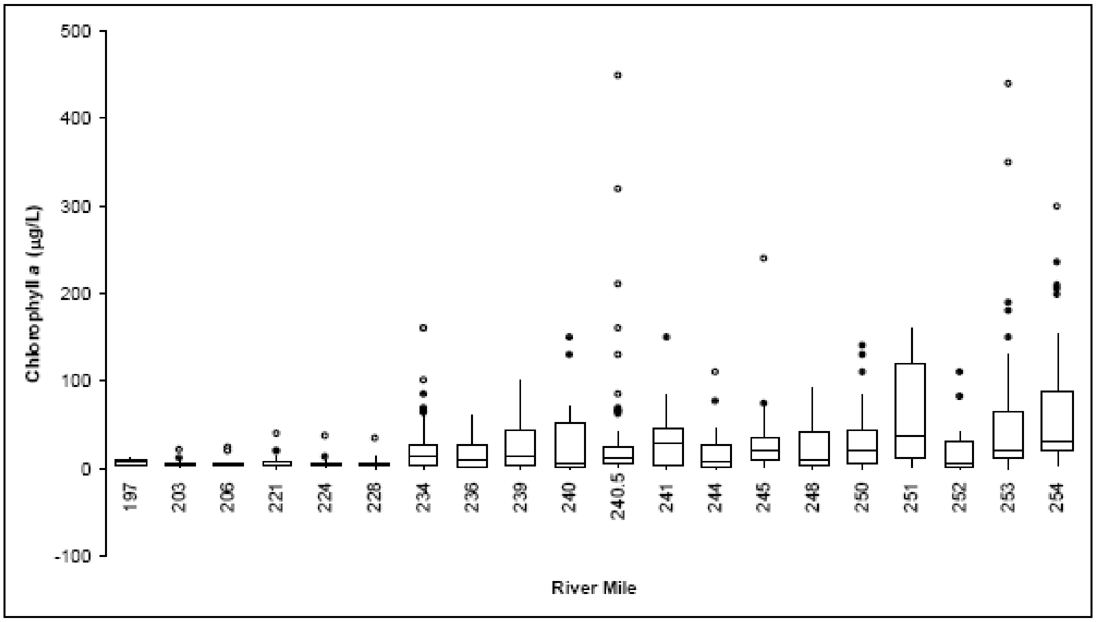


Figure C-26. Box and Whisker Plot of Historical Chlorophyll-*a* Data Collected from Various Sites in the Upper Klamath Basin (Copco 1 Dam Outflow [RM 197] to Link River at Fremont St. Bridge [RM 254]) Between 1950 and 2001. Source: PacifiCorp 2004b.

As with the historical data record, more recent data indicate that high summer chlorophyll-*a* concentrations in the Keno Impoundment (including Lake Ewauna) are due to large populations of algae, predominantly *A. flos-aquae*, entering the Klamath River from Upper Klamath Lake in summer and largely settling out of the water column (FERC 2007, NCRWQCB 2010, Sullivan et al. 2008, et al. 2009, et al. 2010). Chlorophyll-*a* data in the mainstem Klamath River downstream of Upper Klamath Lake follow a seasonal and longitudinal pattern where concentrations tend to be highest (and most variable) at Link River at Klamath Falls (RM 253.1) and decrease toward Keno Dam (RM 235) and the upstream end of J.C. Boyle Reservoir (RM 228.3) (Figures C-27 and C-28). At all locations in this reach, concentrations peak in mid-summer (Sullivan et al. 2008, et al. 2009). For example, for the 2008 growth season, Link River chlorophyll-*a* concentrations range from 9.3 µg/L in May, to 340 µg/L in mid-July, peak in early August at 390 µg/L, and decrease to 8.8 µg/L in November (Figure C-27). Further downstream, in the Keno Impoundment at the Highway 66 bridge, surface chlorophyll-*a* concentrations are considerably lower, peaking at approximately 120 µg/L in mid-July 2008 and 75 µg/L in mid-August, and are generally below 50 µg/L for the rest of the summer. Data reported for 2009 show very high concentrations, with a maximum concentration of 631 µg/L at Link River Dam in early August, 35 µg/L downstream of Keno Dam in late August, and 25 µg/L downstream of J.C. Boyle Dam in late May (Watercourse Engineering, Inc. 2011).

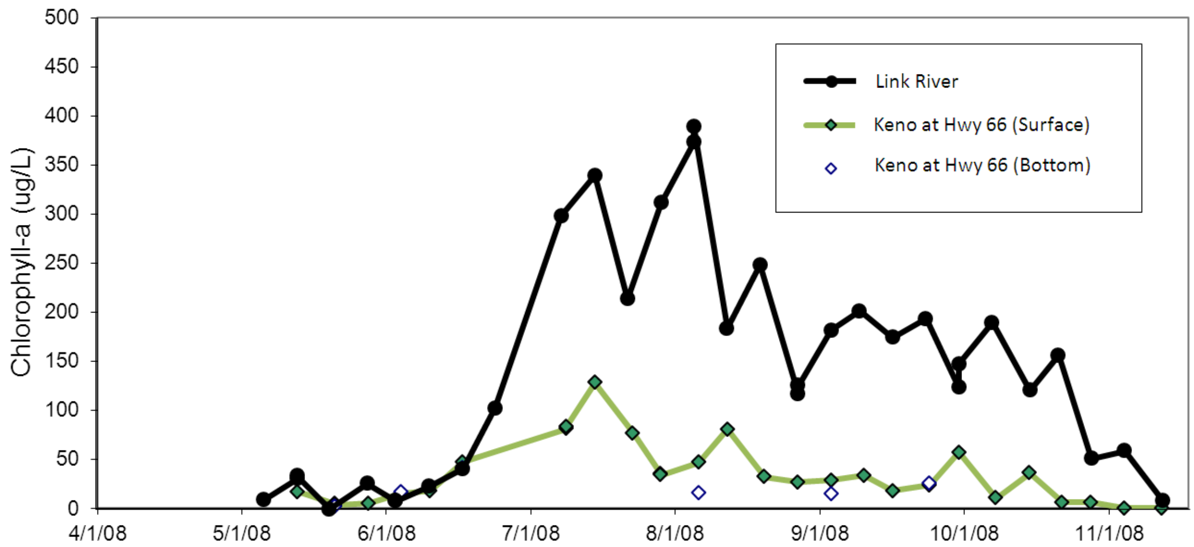


Figure C-27. Decrease in chlorophyll-*a* concentrations from Link River (RM 253.7) to the Keno Impoundment at Highway 66 during May through November, 2008. Graph modified from Appendix B in Sullivan et al. (2009).

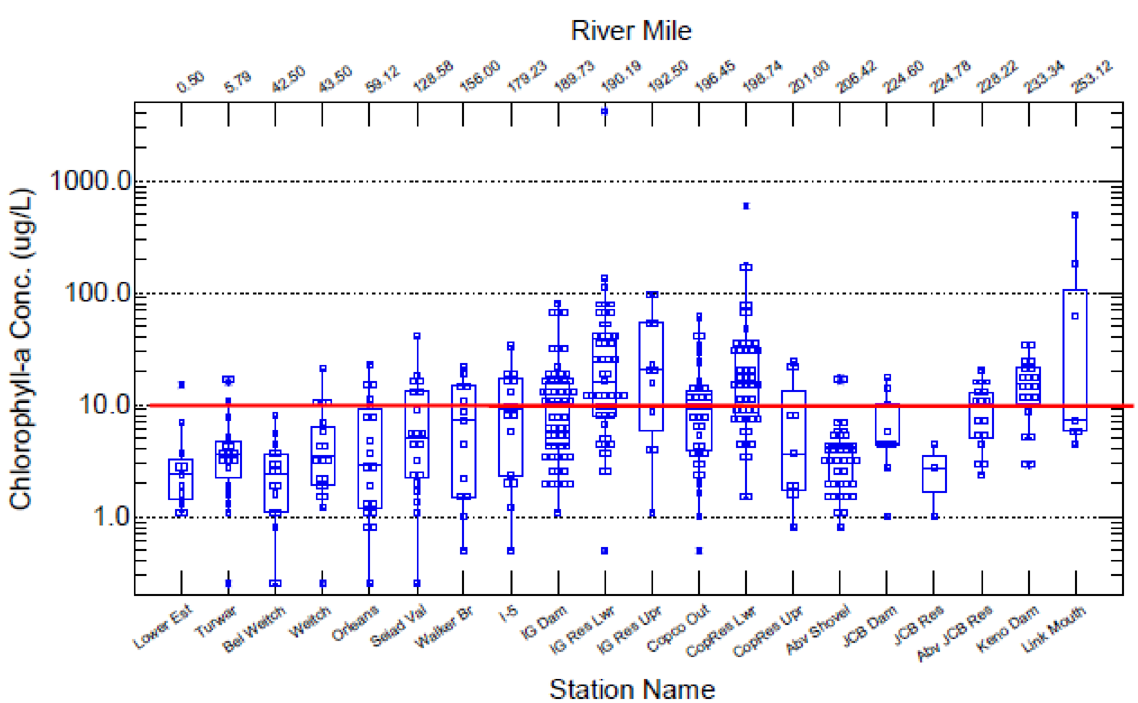


Figure C-28. Longitudinal analysis of summer (May through September) chlorophyll-*a* concentrations from 2005–2007 along the Klamath River. Note the logarithmic scale. Data from the Yurok Tribe, Karuk Tribe of California, North Coast Regional Water Quality Control Board, and PacifiCorp. Source: NCRWQCB 2010.

The seasonal and longitudinal chlorophyll-*a* patterns correspond to patterns measured for algal-derived (organic) suspended material between Link River at Klamath Falls (RM 253.1) and the upstream end of J.C. Boyle Reservoir (RM 228.3) (see Section C.2.1.3), as well as seasonally high SOD and hypoxic dissolved oxygen levels measured in this reach (see Section C.4.1.3).

C.6.1.4 Hydroelectric Reach

Over the past decade, algal toxin and chlorophyll-*a* have become routinely monitored water quality parameters in the Hydroelectric Reach. PacifiCorp chlorophyll-*a* monitoring data for the river upstream of J.C. Boyle Reservoir to just downstream of Iron Gate Dam from 2002 through 2009 (May–October) indicates that annual mean values above 10 µg/L are typical of the dataset and there is generally greater apparent variability upstream of J.C. Boyle Reservoir as compared with just downstream of Iron Gate Reservoir (Raymond 2008, 2009, 2010; PacifiCorp 2004a).

A broader longitudinal analysis of measured chlorophyll-*a* concentrations was conducted using monitoring data compiled during 2005–2007 (May–September) from the Yurok Tribe, Karuk Tribe of California, NCRWQCB, and PacifiCorp (NCRWQCB 2010). Results at numerous locations from the lower Klamath Estuary (RM 0–2) to the Link River Dam (RM 253) demonstrate that median chlorophyll-*a* concentrations within Copco 1 and Iron Gate Reservoirs are 2 to 10 times greater (note the logarithmic scale in Figure C-28) than those documented in free-flowing locations in the mainstem river, with median concentrations greater than 10 µg/L exhibited in the reservoirs and median concentrations less than 10 µg/L exhibited at river locations (NCRWQCB 2010). Upstream, in the Keno Impoundment (including Lake Ewauna), median chlorophyll-*a* concentrations for 2005–2007 are similarly high (i.e., greater than 10 ug/L). Additionally, median chlorophyll-*a* concentrations measured upstream of Copco 1 Reservoir ("Abv Shovel" location in Figure C-28) are greater than those measured downstream of Iron Gate Dam to approximately Seiad Valley ("IG Dam" and "Seiad Val" locations in Figure C-28), suggesting that algal blooms generated in Copco 1 and Iron Gate Reservoirs are exported into the Klamath River downstream of Iron Gate Dam.

Seasonal chlorophyll-*a* patterns in the Hydroelectric Reach indicate that relatively high concentrations can occur during spring diatom blooms (i.e., 30–40 µg/L for Copco 1 and Iron Gate Reservoirs in March 2000–2003), followed by a period of relatively low concentrations, which in previous years (e.g., 2009 and 2010) have included *Anabaena* spp. with sufficient density to require health advisory posting of the reservoirs. A second increase occurs during August and September when dense blooms dominated by both *A. flos-aquae* and *M. aeruginosa* are typical (i.e., 30–60 µg/L for Copco and Iron Gate Reservoir 2000–2003) (FERC 2007).

High chlorophyll-*a* concentrations have also been shown to correlate with the toxigenic cyanobacteria blooms dominated by *Anabaena* spp. and *M. aeruginosa* and sharp increases in microcystin levels above WHO numeric targets (Kann and Corum 2009) and

SWRCB, California Department of Public Health, and Office of Environmental Health and Hazard Assessment (OEHHA) guidelines (Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms [SWRCB 2010b]). Data collected from 2004 through 2009 indicate high levels of microcystin in Copco 1 and Iron Gate Reservoirs, with measured concentrations exceeding the SWRCB/OEHHA public health threshold of 8 µg/L by over 1000 times in Copco Reservoir in 2006, 2007, 2008, and 2009 (Figure C-29) (Kann 2007a–2007d, Kann and Corum 2007 and 2009, Kann et al. 2010a, Jacoby and Kann 2007). Microcystin measured during May–December 2009 at numerous locations in the Klamath River exhibited concentrations less than 1 µg/L, or well below the SWRCB/OEHHA public health threshold of 8 µg/L, at free-flowing river sites from Link River Dam (RM 253) to the Klamath River near Klamath (RM 6) (Watercourse Engineering, Inc. 2011). However, extremely high concentrations (1,000–73,000 µg/L) were measured during algal blooms occurring in July, August, and September in Copco 1 Reservoir in Mallard Cove and Copco Cove, and in Iron Gate Reservoir at Jay Williams (Watercourse Engineering 2011).

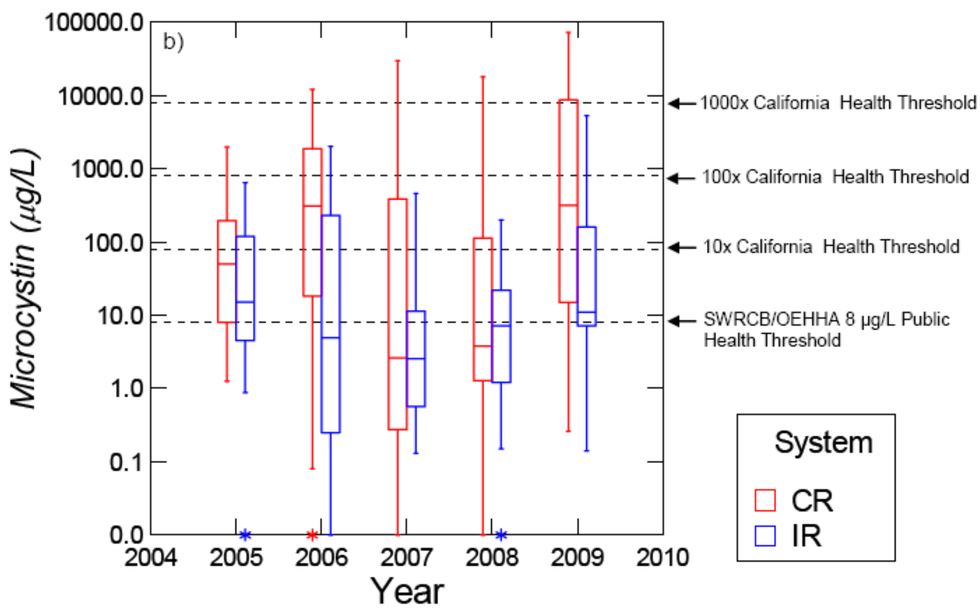


Figure C-29. Inter-annual Comparison of Microcystin Concentration for Copco Reservoir (Red Square) and Iron Gate Reservoir (Blue Square) during July through October 2005–2009. Source: Kann et al. 2010a.

In 2007, a *M. aeruginosa* bloom prompted a Yurok Tribe health advisory along multiple affected reaches in the Klamath River (Kann 2007a–2007d); 85 percent of fish and mussel tissue samples collected during July through September 2007 in the Klamath River, including Iron Gate and Copco 1 Reservoirs, exhibited microcystin bioaccumulation (Kann 2008). Results indicated that all of the WHO total daily intake guideline values were exceeded, including several observations of values exceeding acute total daily intake thresholds (Kann 2008). In a retrospective letter to PacifiCorp (August 6, 2008), the California OEHHA stated that they “would have recommended against consuming mussels from the affected section of the Klamath River, and yellow perch from Iron Gate and Copco Reservoirs, because their average concentrations exceeded 26 nanograms per gram (ng/g),” which is the OEHHA upper bound of advisory tissue levels fish or shellfish consumption (for a single serving per week based on 8 ounces uncooked fish). Data from 2007 also indicate microcystin bioaccumulation in juvenile salmonids reared in Iron Gate hatchery (Kann 2008; see Section 3.3.3.3 Habitat Attributes Expected to be Affected by the Project - Water Quality - Algal Toxins for a discussion of algal toxins as related to fish health). Additional public health advisories were issued in 2009 and 2010 in Copco 1 and Iron Gate Reservoirs, as well as downstream locations in the Klamath River (including locations on the Yurok Reservation), for microcystin levels in ambient and/or freshwater mussel tissue (Kann et al. 2010a, Kann et al. 2010b, Fetcho 2010).

As part of an evaluation of the relationship between *M. aeruginosa* cell density and microcystin concentration, Kann et al. (2010a) compared measured values to the WHO guidelines for a low probability of adverse health effect (20,000 cells/mL *M. aeruginosa,* or 4 µg/L microcystin) and the SWRCB/OEHHA guidelines for protection against a moderate probability of adverse effects (8 µg/L microcystin) for 2009. These results showed that the more conservative guideline of 20,000 cells/mL *M. aeruginosa* decreases the frequency of exceeding the 8 µg/L SWRCB/OEHHA guideline value for microcystin, and is thus more protective of public health. Overall, the 2005–2008 results clearly illustrate that the majority of exceedances to all guidelines and thresholds occurred in the reservoirs in the Hydroelectric Reach (as compared with downstream riverine sites), with the highest overall levels measured in Copco 1 Reservoir (Figure C-30) (Kann and Corum 2009).

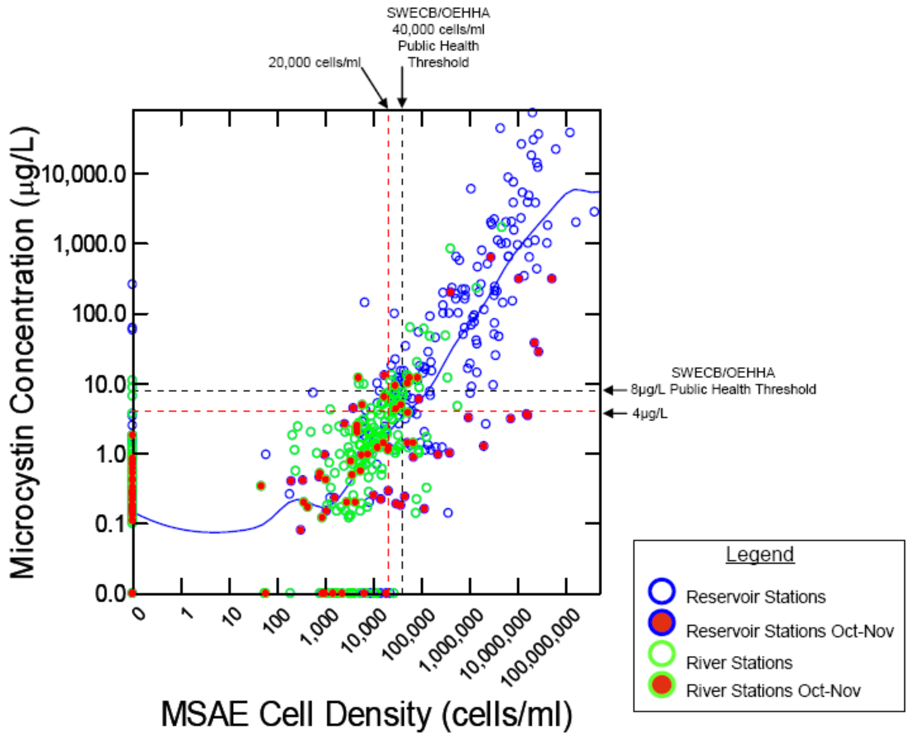


Figure C-30. Relationship between *Microcystis aeruginosa* Cell Density and Microcystin Toxin Concentration for Copco 1 and Iron Gate Reservoirs and Klamath River Stations 2005–2009. Source: Kann et al. 2010a.

C.6.2 Lower Klamath Basin

C.6.2.1 Iron Gate Dam to Salmon River

As discussed above (Section C.6.1.4), 2005–2007 data indicate that during May through September median chlorophyll-*a* concentrations decreased longitudinally with distance downstream of Iron Gate Dam (Figure C-28) and were greater than concentrations measured just upstream of Copco 1 Reservoir. This indicates that algal blooms occurring in the reservoirs were being transported to the downstream river reaches. Ward and Armstrong (2010) report mean annual chlorophyll-*a* concentrations at 5 µg/L for 2001-2005, with concentrations also generally decreasing with distance downstream of Iron Gate Dam (Figure C-31). The highest annual mean value (≈5 µg/L) occurred in 2005 at the confluence with the Shasta River (RM 176.7). In 2009, the Karuk Tribe collected chlorophyll-*a* and pheophytin-*a* (an additional photosynthetic pigment) data from the Klamath River downstream of Iron Gate Dam; chlorophyll-*a* values were approximately 1–35 µg/L and were variable depending on location. Generally speaking, relatively greater values were observed at upstream locations near Iron Gate Dam (RM 190.1) and Walker Bridge sites, but the peak value was observed farther downstream at Orleans (RM 59) (Karuk Tribe of California 2010).

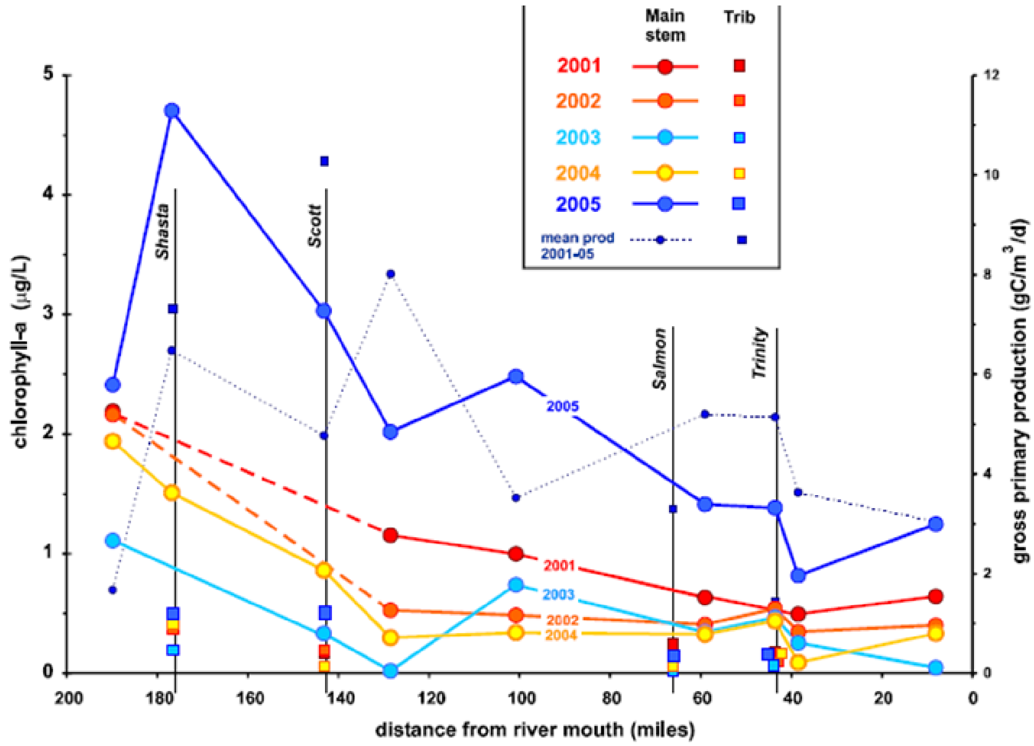


Figure C-31. Annual mean values of chlorophyll-*a* in the Klamath River downstream of Iron Gate Dam during June–September 2001–2005. Source: Ward and Armstrong (2010).

In 2008, the Karuk Tribe collected cyanobacteria concentration (cells/mL) using optical phycocyanin probes to allow more timely assessment of public health threats from toxigenic algal species. Data from downstream of Iron Gate Dam collected during June–October indicated peak values (>25,000 cells/mL) in July and early-to-mid September (Karuk Tribe of California 2009).

Although concentrations of both *M. aeruginosa* and microcystin toxin in the Klamath River downstream of the Hydroelectric Reach are lower relative to the reservoirs (Figure C-32), WHO guidelines for exposure to microcystin (i.e., < 4 µg/L) have been exceeded downstream of Iron Gate Dam on numerous occasions (Kann 2004, Kann and Corum 2009, Kann et al. 2010a, Fetcho 2010), including late-summer/early-fall *M. aeruginosa* blooms in September 2007, 2009, and 2010 from Iron Gate Dam (RM 190.1) to the mouth of the Klamath River (RM 0.0). Health Advisories were posted along this reach of the Klamath River (Iron Gate Dam to Shasta River in 2009 and 2010, due to elevated microcystis cell counts and/or microcystin concentrations in river water. Available data indicate that algal blooms in Iron Gate and Copco Reservoirs have been responsible for the public health exceedances in the lower river (Kann and Corum 2009).

Additionally, data from 2007 indicate microcystin bioaccumulation in juvenile salmonids reared in Iron Gate hatchery (Kann 2008) and, in 2010, algal toxins were found in salmonid tissues collected near Happy Camp (Kann et al. 2011) (see Section 3.3.3.3 Habitat Attributes Expected to be Affected by the Project - Water Quality - Algal Toxins for a discussion of algal toxins as related to fish health).

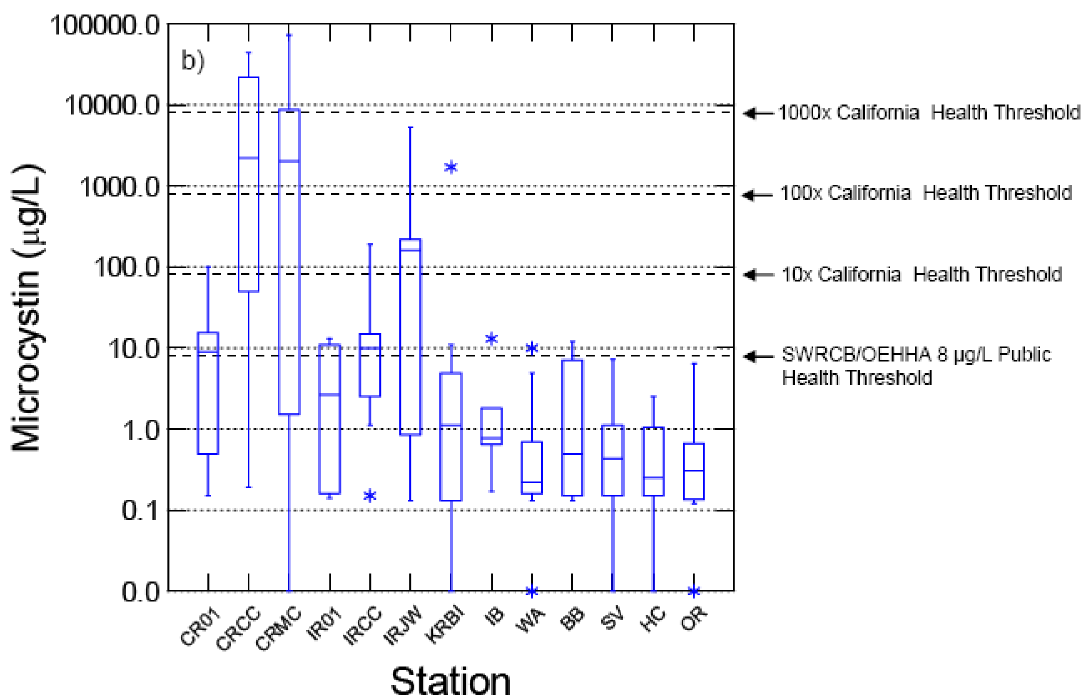


Figure C-32. Microcystin Concentration in Klamath River from Copco 1 (CR01) to Orleans (RM 59) during June–November, 2009. WA=Walker Bridge, SV=Seiad Valley (RM 128), OR=Orleans (RM 59). Source: Kann et al. 2010a.

C.6.2.2 Salmon River to Estuary

Downstream of the confluence with the Salmon River (RM 66.0), algal toxin and chlorophyll-*a* concentrations exhibit variability and are generally lower than those measured farther upstream. During 2009, mean microcystin concentrations from Orleans (RM 57) to Klamath River at Klamath (RM 6.0) were less than 1 µg/L, or well below the SWRCB/OEHHA public health threshold of 8 µg/L (Watercourse Engineering, Inc. 2011). Individual microcystin measurements generally remained less than 1 µg/L as well, with the exception of a sample collected in late-September at Orleans (RM 59.1) for which the concentration was just over 6 µg/L (Watercourse Engineering, Inc. 2011).

For several years, the Yurok Tribe has measured chlorophyll-*a*, cyanobacteria concentrations (cells/mL), and has used optical phycocyanin probes to allow more timely assessment of public health threats from toxigenic algal species on the Yurok Reservation. Chlorophyll-*a* data measured from Weitchpec (RM 43.5) to the estuary during 2003–2004 indicate that, where detectable, concentrations were generally below 5 µg/L. From May–July during 2006–2010 chlorophyll-*a* concentrations were consistently less than 5 µg/L, but increased in during August–October to approximately 20–30 µg/L (Sinnott 2008, 2009, 2010, 2011). Peak values on the Yurok Reservation consistently occurred at Weitchpec (RM 43.5) from late August to mid-October and varied by year (6.7 µg/L in 2008 and 26 µg/L in 2009). In contrast, 2001–2005 chlorophyll-*a* data from Ward and Armstrong (2010) show small relative increases in chlorophyll-*a* with distance downstream, from near the Trinity River confluence (RM 40) to Turwar (RM 5.8), (Figure C-31), suggesting that algal productivity may increase slightly as water moves toward the Klamath Estuary.

As described for the Klamath River from Iron Gate Dam to the Salmon River (Section C.6.2.1), there have been numerous exceedances of public health guidelines in the Klamath River from the Salmon River confluence to the Klamath Estuary, particularly in 2010. Public health advisories were issued in 2009 and 2010 in this reach (including locations on the Yurok Reservation) for elevated microcystin levels in ambient and/or freshwater mussel tissue samples (Kann et al. 2010a, Kann et al. 2010b, Fetcho 2010). In addition, substantial bioaccumulation (exceeding public health guidelines) of microcystin in freshwater mussels has been shown in this reach (Kann 2008, Kann et al. 2010b). See Section 3.3.3.3 Habitat Attributes Expected to be Affected by the Project - Water Quality - Algal Toxins for a discussion of algal toxins as related to fish health.

C.6.2.3 Klamath Estuary

Chlorophyll-a and algal toxin levels in the Klamath Estuary are generally similar to those measured at stations just upstream. From May–July during 2006–2010, chlorophyll-a concentrations in the Klamath Estuary were consistently less than 5 ug/L, increasing slightly during August–October to approximately 1–8ug/L (Sinnott 2008, 2009a, 2009b, 2010, 2011). Peak concentrations of chlorophyll-a during 2006-2010 occurred during late-August to mid-October and varied by year (2.4 ug/L in 2006, 8ug/L in 2009 and 2010).

Algal toxin concentrations in the estuary are generally low, corresponding to relatively low concentrations of *M. aeruginosa*. Exceptions to this include in September 2007 and 2010 when the Yurok Tribe issued advisories because M. aeruginosa concentrations exceeded 40,000 cells/mL, by more than a factor of 2, and in one additional instance in September 2005, concentrations exceeded the WHO guideline for low risk recreational use (20,000 cells/mL). These elevated levels of *M. aeruginosa* corresponded with elevated levels measured farther upstream in Copco 1 and Iron Gate Reservoirs, indicating that *M. aeruginosa* was being transported into the estuary from upstream reservoir blooms (Kann and Corum 2006). See Section 3.3.3.3 Habitat Attributes

Expected to be Affected by the Project - Water Quality - Algal Toxins for a discussion of algal toxins as related to fish health. Lastly, there is emerging evidence that cyanotoxins flushing from coastal rivers into Monterey Bay, California were responsible for numerous sea otter deaths in 2007 (Miller et al. 2010). While it is not known if conditions in Monterey Bay are similar to those in the Klamath River marine nearshore environment, there may be potential for microcystin to adversely impact marine organisms when large blooms are transported through the Klamath Estuary and into the Pacific Ocean.

C.7 Inorganic and Organic Contaminants

C.7.1 Upper Klamath Basin

In general, information regarding contaminants in the Upper Klamath Basin upstream of the Hydroelectric Reach is unavailable. Human activities such as illegal dumping may be a source of inorganic and organic contaminants to the lower Sprague and Williamson river sub-basins (Rabe and Calonje 2009). The exception to this is arsenic; natural geologic sources of arsenic may be causing relatively high levels of this chemical element in the Upper Klamath Basin, as is the case other south central and southeastern Oregon basins (Sturdevant 2010). Recently collected data from a limited number of locations indicate arsenic levels of <1 µg/L to >10 µg/L in surface waters of the Upper Klamath Basin. Limited data are available partly because 5.0 µg/L was the established quantitative limit for the state of Oregon until 2008. It is not known whether these levels represent solely natural geologic sources or are elevated due to anthropogenic activity (Sturdevant 2010).

C.7.1.1 Hydroelectric Reach

<u>Water Column Contaminants</u>

Existing water quality data are available from the California Surface Water Ambient Monitoring Program (SWAMP), which collected water quality data, including inorganic and organic contaminant data, from 2001 through 2005 at eight monitoring sites from the California-Oregon state line (RM 208.5) to Klamath River at Klamath Glen (RM 5.8) (NCRWQCB 2008). Results from the state line site 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 at the time of sampling. Aluminum concentrations (50.7–99.2 µg/L) may have exceeded the United States Environmental Protection Agency (USEPA) continuous concentration for freshwater aquatic life protection (87 µg/L) on two of four site visits (50 percent exceedance rate), and exceeded the USEPA secondary Maximum Contaminant Level (MCL) for drinking water (50 µg/L) on all four site visits (100 percent exceedance rate) (NCRWQCB 2008). Grab samples were analyzed for 100 pesticides, pesticide constituents, isomers, or metabolites; 50 polychlorinated biphenyls (PCBs) congeners; and 6 phenolic compounds. Results indicated no PCBs detections, but one detection of dichlorodiphenyldichloroethylene (1,1-bis-(4-chlorophenyl)-2,2-dichloroethene or DDE) (25 percent of samples) and one detection of trans-nonachlor (25 percent of samples) were found (NCRWQCB 2008).

Sediment Contaminants

To investigate the potential for toxicity of the sediments trapped behind the KHP reservoirs, Shannon & Wilson, Inc. (2006) collected 26 cores from J.C. Boyle, Copco 1, and Iron Gate Reservoirs during 2004–2005 and analyzed them 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, Inc. 2006). While cyanide was detected in multiple sediment cores, it 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, a known carcinogen, was measured in three samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs. Long-term exposure to dioxin in humans is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. In the 2004–2005 reservoir samples, measured levels were 2.48–4.83 pg/g (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations)) and did not exceed Puget Sound Dredged Disposal Analysis screening levels (Shannon & Wilson, Inc. 2006). More comprehensive reviews of dioxin guidelines and sediment studies from watersheds outside of the Klamath basin were conducted by Dillon (2008) and USEPA (2010b), the latter presenting an estimate of background dioxin concentrations (2–5 ppt) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010). Based on the information presented in (USEPA 2010), in addition to being within the range of natural background, Klamath dioxin sediment levels reported by Shannon & Wilson (2006) are one to three orders of magnitude below risk-based USEPA (1,000 pg/g dry weight [DW], toxicity equivalent quotient [TEQ]) preliminary remediation goals in residential soils, and Washington Department of Ecology (11 pg/g DW TEQ) for residential soil clean-up levels (USEPA 2010). They are also generally an order of magnitude below USEPA effects-based ecological receptors thresholds (60–100 pg/g DW TEQ for fish; 2.5–25 pg/g DW TEQ for mammals; 21–210 pg/g DW TEQ for birds). Oregon human health thresholds include risk-based values for subsistence fishers as well as the general consuming public, and hence these values are quite a bit lower (0.0011–1.1 pg/g DW TEQ), with the low end of the range applicable to subsistence fishers (ODEQ 2007). Oregon's dioxin wildlife thresholds include levels at which dioxin would bioaccumulate for the protection of wildlife consumers (0.56 pg/g DW TEQ for fish; 0.052–1.4 pg/g DW TEQ for mammals; 0.7–3.5 pg/g DW TEQ for birds), which are also generally lower than the USEPA effects-based thresholds.

While the existing sediment data (Shannon & Wilson, Inc. 2006) did not indicate a high risk of sediment toxicity, it was not sufficient to evaluate all analytes of interest. Thus, as part of the Secretarial Determination studies, a sediment evaluation was undertaken during 2009–2011 to provide a more comprehensive data set to further guide decision makers in an evaluation of potential impacts from dam removal. The Bureau of Reclamation (Reclamation) and USFWS plan (report in process) expanded the number of sediment cores and the analyte suite examined, including chemicals likely to bioaccumulate, and included biological and elutriate tests (Reclamation 2010). For this evaluation, establishment of toxicity and/or bioaccumulative potential for sediment contaminants relied upon 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 (SLVs). Sediment cores were collected at multiple sites and at various sediment depths per site in J.C. Boyle Reservoir (n=26), Copco 1 Reservoir (n=25), Iron Gate Reservoir (n=24), and the Klamath Estuary (n=2), for a total of 77 samples (Department of the Interior 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. Using results of these analyses, the following five exposure scenarios were evaluated under Level 2A and 2B of the SEF using multiple lines of evidence: (CDM 2011):

- Scenario 1 – No Action Alternative - Long-term sediment exposure for aquatic biota and humans (via fish consumption) to reservoir sediments.
- Scenario 2 – Proposed Action - Short-term water column exposure for aquatic biota from sediments flushed downstream (suspended sediments, not a bioaccumulation issue).
- Scenario 3 – Proposed Action - Long-term sediment exposure for riparian biota and humans from reservoir terrace deposits and river bank deposits (terrestrial exposures).
- Scenario 4 – Proposed Action - Long-term sediment exposure for aquatic biota and humans from river bed deposits (aquatic exposures).
- Scenario 5 – Proposed Action - Long-term sediment exposure for aquatic biota from estuary and marine near shore deposits.

Based on comparisons of sediment chemistry to screening levels (SLs) and the results of bioassays (see Section C.7.1.1. for more detail), the reservoir sediments do not appear to be highly contaminated. No consistent pattern of elevated chemical composition was observed across discrete sampling locations within a reservoir and no single reservoir was observed to be consistently more or less contaminated. Sediment in all three reservoirs exceeded ecological SLs for nickel, iron, and 2,3,4,7,8-PECDF. Several pesticides and semi-volatile organic compounds (SVOCs) were not detected; yet, the reporting limits were above the SLs, so other lines of evidence were used to asses these compounds. Similarly, human health SLs were only exceeded for arsenic and nickel, and some legacy pesticides and dioxin-like compounds exceeded the ODEQ Bioaccumulation SLVs. Several pesticides and SVOCs were not detected; yet, the reporting limits were above SLs. Sediment in J.C. Boyle Reservoir does have marginally higher chemical concentrations and more detected chemicals of potential concern (COPCs) as compared to Copco 1 and Iron Gate Reservoir and Klamath Estuary sediments (CDM 2011).

Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species; the exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for sediment toxicity (CDM 2011). 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. TEQs ranged from approximately 4-9 pg/g for J.C. Boyle Reservoir, 5-10 pg/g for Copco 1 Reservoir, and 2-4 pg/g for Iron Gate Reservoir. In some cases these values are slightly higher than background values reported by USEPA for Region 9 (i.e., 2-5 pg/g), Region 10 (i.e., 4 pg/g), and for non-impacted lakes of the United States (i.e., 5.3 pg/g) (USEPA 2010, CDM 2011). The calculated TEQs may also be within the range of local background values. Since the TEQs are only slightly above regional background concentrations and the nationwide background for non-impacted lakes, they have limited potential for adverse effects for fish exposed to reservoir sediments (CDM 2011).

Lastly, sediment samples were also evaluated for levels of known bioaccumulative compounds; ODEQ bioaccumulation sediment SLVs were not exceeded in J.C. Boyle Reservoir sediments, with the exception of a small number of samples for DDTs (i.e., 4,4’-DDT, 4,4’-DDD, 4,4’-DDE) (CDM 2011).

Overall, using multiple lines of evidence from the 2009-2010 Secretarial Determination study, sediment quality of reservoir sediments does not appear to be highly contaminated. No consistent pattern of elevated chemical composition is observed across discrete sampling locations within a reservoir. No single reservoir is observed to be consistently more or less contaminated based on multiple lines of evidence. Where elevated concentrations of chemicals in sediment are found, the degree of exceedance based on comparisons of measured (i.e., detected) chemical concentrations to SLs is small and in several cases may reflect regional background conditions (CDM 2011).

Contaminants in Aquatic Biota

Separate assessments of contaminants in fish tissue for the Hydroelectric Reach have been undertaken by SWAMP and PacifiCorp. SWAMP data include sport fish tissue samples collected during 2007 and 2008 to evaluate accumulated contaminants in nearly 300 lakes statewide. Sport fish were sampled to provide information on potential human exposure to selected contaminants and to represent the higher aquatic trophic levels (i.e., the top of the aquatic food web).

In the Hydroelectric Reach, fish tissue samples were collected in Copco 1 and Iron Gate Reservoirs and analyzed for total mercury, selenium, and PCBs (Iron Gate Reservoir only) (Davis et al. 2010). SWAMP data for Iron Gate and Copco reservoirs (Table C-5) indicate mercury tissue concentrations above the USEPA criterion of 300 ng/g methylmercury in fish tissue to protect the health of consumers of noncommercial freshwater fish; and greater than the OEHHA public health guideline levels advisory tissue level (Klasing and Brodberg 2008) for consumption for 3 and 2 servings per week (70 and 150 ng/g wet weight, respectively) and the fish contaminant goal (220 ng/g wet weight). Measured selenium concentrations were 3–4 orders of magnitude lower than OEHHA thresholds of concern (2,500–15,000 ng/g wet weight) and PCB concentrations were below the lowest OEHHA threshold (i.e., fish contaminant goal of 3.6 ng/g wet weight) (Davis et al. 2010).

Table C-5. Total Mercury, Selenium, and PCBs in (ng/g wet weight) in Largemouth Bass taken from Iron Gate and Copco 1 Reservoirs During 2007–2008 (Davis et al. 2010).

Contaminant	Species	Iron Gate Reservoir	Copco 1 Reservoir
Methylmercury	Largemouth Bass (LMB)	330	310
Selenium	LMB	80	80
PCBs	LMB	1.31	*Not reported*

In a screening-level study of potential chemical contaminants in fish tissue in Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, and in Upper Klamath Lake, PacifiCorp analyzed metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine (pesticide) compounds, and PCBs in largemouth bass (*Micropterus salmoides*) and black bullhead catfish (*Ameiurus melas*) (PacifiCorp 2004c). PacifiCorp reported that, in general, contaminant levels in fish tissue are below both screening level values for protection of human health (USEPA 2000) and recommended guidance values for the protection of wildlife (MacDonald 1994). Exceptions to this include measured fish tissue levels of total mercury in samples from Copco 1 and Iron Gate Reservoirs as compared to the wildlife screening level of 0.00227 ug/g and measured fish tissue levels of arsenic (<0.3 ug/g) that PacifiCorp indicated may equal or exceed the toxicity screening level for subsistence fishers (0.147 ug/g) in samples of largemouth bass from J.C. Boyle, Copco 1, and Iron Gate Reservoirs. Subsequent reanalysis of the PacifiCorp mercury tissue data indicates that all tissue samples exceed the most protective wildlife screening level of 0.00227 ug/g, samples from Keno, J.C. Boyle, Copco 1, and Iron Gate Reservoirs exceed the screening level for subsistence fishers (0.049 ug/g), and samples from Copco 1 and Iron Gate Reservoirs exceed the screening level for recreational fishers (0.4 ug/g) (Table C-6).

Table C-6. Total Mercury Concentrations (ug/g wet weight) in Black Bullhead (BB) and Largemouth Bass (LMB) Composite Tissue Samples taken from Project Reservoirs and Upper Klamath Lake in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	Total Mercury (ug/g wet weight)[1]
L-262-03	1F	Keno Impoundment	BB	0.121
L-262-03	1F Duplicate	Keno Impoundment	BB	0.125
L-262-03	2F	J.C. Boyle Reservoir	LMB	0.153
L-262-03	3F	J.C. Boyle Reservoir	LMB	0.190
L-273-03	1F	Iron Gate Reservoir	LMB	0.564
L-273-03	2F	Iron Gate Reservoir	LMB	0.508
L-273-03	3F	Copco 1 Reservoir	LMB	0.563
L-273-03	4F	Copco 1 Reservoir	LMB	0.389
L-484-03	1F	Upper Klamath Lake	BB	0.031
L-484-04	2F	Upper Klamath Lake	BB	0.035
		Method Detection Limit		0.003[2]
		Method Reporting Limit		0.007[2]
		Screening Levels[3]:		
		Recreational fishers		0.4
		Subsistence fishers		0.049
		Wildlife		0.00227

[1] PacifiCorp (2004c) total mercury data was provided in ng/g dry weight. Data was converted to ug/g wet weight using percent moisture data provided for each sample by Moss Landing Marine Laboratory (A. Bonnema, pers. comm., 17 February 2011).

[2] The Method Detection Limit and Reporting Limit were converted from dry weight to wet weight using an average of the percent moisture data for all samples.

[3] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

Additionally, PacifiCorp indicated that some of the fish tissue samples from Upper Klamath Lake, Keno Impoundment, J.C. Boyle Reservoir, and Copco 1 Reservoir exceed the suggested wildlife screening value for total DDTs (Table C-7) (DDE,p,p' was detected; however DDT and DDD were not detected in the study), and total PCB values exceed the screening level for subsistence fishers in black bullhead from Keno Impoundment, and in largemouth bass from J.C. Boyle, Copco 1, and Iron Gate Reservoirs (Table C-8). Dioxins were not tested.

Table C-7. Total DDE Concentration (ng/g) in Black Bullhead (BB) and Large Mouth Bass (LMB) Composite Tissue Samples taken from Project Reservoirs and Upper Klamath Lake in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	DDE,p,p' (ng/g wet weight)
L-262-03	1F	Keno Impoundment	BB	2.41
L-262-03	2F	J.C. Boyle Reservoir	LMB	<2.00
L-262-03	2F Duplicate	J.C. Boyle Reservoir	LMB	<2.00
L-262-03	3F	J.C. Boyle Reservoir	LMB	2.91
L-273-03	1F	Iron Gate Reservoir	LMB	<2.00
L-273-03	2F	Iron Gate Reservoir	LMB	<2.00
L-273-03	3F	Copco Reservoir	LMB	2.16
L-273-03	4F	Copco Reservoir	LMB	<2.00
L-484-03	1F	Upper Klamath Lake	BB	<2.00
L-484-04	2F	Upper Klamath Lake	BB	2.32
		Method Detection Limit		0.56
		Method Reporting Limit		2
		Screening Levels[1] (for Total DDTs):		
		Recreational fishers		117
		Subsistence fishers		14.4
		Wildlife		0.2–1.07

[1] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

Table C-8. Total PCB Concentrations (ng/g) in Black Bullhead (BB) and Large Mouth Bass (LMB) Composite Tissue Samples taken from Project Reservoirs and Upper Klamath Lake in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	Total PCB (ng/g wet weight)
L-262-03	1F	Keno Impoundment	BB	2.926
L-262-03	2F	J.C. Boyle Reservoir	LMB	0.885
L-262-03	2F Duplicate	J.C. Boyle Reservoir	LMB	1.397
L-262-03	3F	J.C. Boyle Reservoir	LMB	3.521
L-273-03	1F	Iron Gate Reservoir	LMB	6.574
L-273-03	2F	Iron Gate Reservoir	LMB	4.909
L-273-03	3F	Copco Reservoir	LMB	2.822
L-273-03	4F	Copco Reservoir	LMB	2.158
L-484-03	1F	Upper Klamath Lake	BB	0.846
L-484-04	2F	Upper Klamath Lake	BB	2.015
		Method Detection Limit		Varies
		Method Reporting Limit		0.2
		Screening Levels[1]:		
		Recreational fishers		20
		Subsistence fishers		2.45
		Wildlife		100

[1] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

To supplement existing fish tissue data and provide additional lines of evidence in the Secretarial Determination sediment evaluation, the potential for chemicals in sediment and elutriate samples to bioaccumulate in aquatic species at concentrations above screening levels for ecological receptors (i.e., fish, birds, humans/mammals) was investigated (CDM 2011). Bioaccumulation studies were conducted using laboratory invertebrates (Asian clams, *Corbicula fluminea*; and Black worms, *Lumbriculus variegates*) exposed to reservoir-derived sediments and two species of field-caught fish (yellow perch and bullhead) collected during late September 2010 from J.C. Boyle, Copco 1, and Iron Gate Reservoirs (Reclamation/USFWS in prep, see Section C.7.1.1 for more detail). Results indicate that multiple chemicals were found in invertebrate tissue (i.e., acenaphthene, arsenic, benzo(a)pyrene, DDD/DDE, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, hexachlorobenzene, lead, mercury, phenanthrene, pyrene, total PBDEs, total PCBs). Of these detected chemicals, only fluoranthene possesses a toxicity reference value (TRV) for the species tested; exceedances of the fluoranthene TRV were only identified above the No Effect TRV, and were below the Low Effect TRV. Tissue-based TRVs are unavailable for the remaining invertebrate chemicals detected, and hexachlorobenzene has no tissue-based TRVs (i.e., for any species). Multiple chemicals were found in fish tissue (i.e., 2,3,7,8-TCDD, arsenic, DDE/DDT, dieldrin, endrin, mercury, mirex, selenium, and total PCBs) as well (CDM 2011). Mercury exceeded tissue-based TRVs for perch in Iron Gate Reservoir and bullhead samples in all three reservoirs (CDM 2011). TRVs are not available the remaining several chemicals detected in yellow perch and bullhead samples.

C.7.2 Lower Klamath Basin

C.7.2.1 Iron Gate Dam to Salmon River

Water Column Contaminants

SWAMP collected water quality data for inorganic and organic contaminants from 2001 through 2005 at eight monitoring sites from the California-Oregon state line (RM 208.5) to Klamath River at Klamath Glen (RM 5.8) (NCRWQCB 2008). As was the case for the SWAMP state line site (Section C.7.1.1), results for the four sites in the reach from Iron Gate Dam to the Salmon River indicated that with the exception of aluminum, all other measured concentrations of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc) were in compliance with all water quality objectives at the time of sampling. Aluminum concentrations (26.30–280.0 µg/L) potentially exceeded the USEPA continuous concentration for freshwater aquatic life protection (87 µg/L) on 23 of 59 site visits (39 percent exceedance rate), exceeded the USEPA secondary MCL for drinking water (50 µg/L) on 37 site visits (63 percent exceedance rate), and exceeded the California Department of Health Services secondary MCL for drinking water (200 µg/L) on five site visits (8 percent exceedances rate) (NCRWQCB 2008).

Sediment Contaminants

Sediment data for inorganic and organic contaminants in the Klamath River from Iron Gate Dam to the Salmon River are not readily available, nor are fish tissue analyses for contaminants in the lower Klamath River.

C.7.2.2 Salmon River to Estuary

Water Column Contaminants

SWAMP collected water quality data for inorganic and organic contaminants from 2001 through 2005 at three monitoring sites in this reach of the Klamath River to Klamath Glen (RM 5.8) (NCRWQCB 2008). With the exception of aluminum, all other measured concentrations of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) were in compliance with all water quality objectives at the time of sampling. Aluminum concentrations (8.80 to 565.00 µg/L) potentially exceeded the USEPA continuous concentration for freshwater aquatic life protection (87 µg/L) on 12 of 28 site visits (43 percent exceedance rate), exceeded the USEPA secondary MCL for drinking water (50 µg/L) on 15 site visits (54 percent exceedance rate), and exceeded the California Department of Health Services secondary MCL for drinking water (200 µg/L) on four site visits (14 percent exceedances rate). At one station (Klamath River at Klamath Glen [RM 5.8]), grab samples were analyzed for 100 pesticides, pesticide constituents, or pesticide metabolites; 50 PCB congeners; and 6 phenolic compounds. There were no PCB detections, but the pesticide disulfoton was detected in one sample. Disulfoton is a systemic organophosphate insecticide for which there is no numeric water quality objective.

Sediment Contaminants

Sediment data for inorganic and organic contaminants in the Klamath River from the Salmon River to the estuary are limited. The Yurok Tribe is currently conducting a bioaccumulation study to evaluate levels of bioaccumulatory chemicals in a number of aquatic species; work began in spring of 2010 and is ongoing. Data are not yet available for inclusion in this Klamath Facilities Removal EIS/EIR.

C.7.2.3 Klamath Estuary

Sediment and water column data for inorganic and organic contaminants in the Klamath Estuary are not readily available. However, contaminant conditions in the estuary (RM 0–2) are likely to be similar to those a few miles upstream at the site for which SWAMP data have been recently collected (see previous section).

As part of the Secretarial Determination studies, a sediment evaluation is evaluating potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the dams under the Proposed Action. Sediment cores were collected during 2009–2010 at multiple sites and at various sediment depths per site, including two locations in the Klamath Estuary (see Section C.7.1.1). Overall, using multiple lines of evidence from the 2009-2010 Secretarial Determination study, sediment quality in the Klamath Estuary does not appear to be highly contaminated. Where elevated concentrations of chemicals in sediment were found (i.e., arsenic, chromium, iron, nickel, bis[2-ethylhexyl]phthalate), the degree of exceedance based on comparisons of measured (i.e., detected) chemical concentrations to SLs was small and in several cases (i.e., arsenic, nickel) may reflect regional background conditions (CDM 2011). The results of the acute toxicity bioassays for the midge and the amphipod identified no statistically significant difference in survival of either test organism exposed to estuary sediments compared to control sediments. As with the reservoir sediments (Section C.7.1.1), the lone chemical identified in tissue from invertebrates exposed to estuary sediments above TRVs was fluoranthene. Further, it was only identified above the No Effect TRV, and was below the Low Effect TRV. TEQs for dioxin, furan, and dioxin-like PCBs were all below 0.2 pg/g for the Klamath Estuary, thus adverse effects from exposure to TEQs are not expected following exposure to sediment in the estuary (CDM 2011).

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Appendix D
Water Quality Environmental Effects Determination Methodology Supplemental Information

D.1 Available Numeric Models for Analysis of the Proposed Action and Alternatives

For the Federal Energy Regulatory Commission relicensing process, PacifiCorp developed the Klamath River Water Quality Model (KRWQM) (Watercourse Engineering, Inc. 2003, PacifiCorp 2004), consisting of linked Resource Management Associates (RMA) RMA-2 and RMA-11-dimensional models for riverine segments, where RMA-2 simulates riverine hydrodynamics and RMA-11 simulates water quality processes, and the 2-dimensional CE-QUAL-W2 model is used for water quality in reservoir segments. The KRWQM does not include a segment for the Klamath River Estuary. The KRWQM possesses the following attributes (Tetra Tech 2009a):

- Uses proven and generally accepted hydrodynamic and water quality models, including historical application to the Klamath River;
- Has been reviewed by a number of stakeholders in the watershed;
- Can be directly compared to many Oregon Department of Environmental Quality (DEQ), North Coast Regional Water Quality Control Board (NCRWQCB) and tribal water quality criteria;
- Has been calibrated for the Klamath River; and,
- Uses the public domain model CE-QUAL-W2 and a version of RMA that can be distributed to the public.

While the KRWQM possesses many beneficial attributes, the computationally intensive nature of the model components and the fine temporal scale of the output means that application of this model to Project alternatives analyzed for the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) over the period of analysis (i.e., 50 years) is not practical. Numeric models used to develop water quality effects determinations for the Proposed Action and Alternatives are presented in Table D-1.

KRWQM results for water temperature and dissolved oxygen compare the existing condition (all Project dams in place) to four without-dams scenarios (i.e., without Iron Gate Dam [“WIG”]; without Copco 1, Copco 2, and Iron Gate Dams [“WIGC”]; without

J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams ["WIGCJCB"]; and without Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams ["WOP" and "WOP2"]). Model runs were calibrated using data from calendar years 2001–2004 (PacifiCorp 2004). General modeling assumptions in comparison to conditions considered for the Klamath Facilities Removal EIS/EIR water quality effects analyses are presented in Table D-2. Limitations, and sources of uncertainty for the KRWQM are presented in Watercourse Engineering, Inc. (2003).

For development of Klamath River Total Maximum Daily Loads (TMDLs) in Oregon and California, Oregon DEQ, NCRWQCB, and the United States Environmental Protection Agency (USEPA) Regions 9 and 10 collaborated to enhance the existing KRWQM (see also Section 3.2.2.4) by revisiting assumptions for several model algorithms and including the 3-dimensional Environmental Fluid Dynamics Code model to represent water quality in the Klamath River Estuary. Algorithm enhancements are described in Tetra Tech (2009a). The Klamath TMDL model was calibrated for water temperature, dissolved oxygen, nutrients (TP, TN, ortho-phosphorus, nitrate, ammonia), and pH using year 2000 data, with the exception of the estuary segment which was calibrated using year 2004 data. Additional model corroboration was conducted for model segments 1 through 5 (within Oregon) using data from year 2002, indicating that the Klamath TMDL model scenarios reproduce general temporal and spatial trends in the observed data (Tetra Tech 2009a). Four simulated scenarios were run for the Klamath TMDL model including the following (Tetra Tech 2009b):

- Natural conditions baseline scenario (T1BSR) – applies to the Upper and Lower Klamath Basin;
- Oregon TMDLs allocation scenario (TOD2RN) – applies to the Upper Klamath Basin to the California-Oregon state line (RM 208.5);
- California TMDLs allocation scenario (TCD2RN) – applies to the Upper Klamath Basin downstream of the California-Oregon state line (RM 208.5) and the Lower Klamath Basin; and,
- With-dams Oregon and California TMDLs scenario (T4BSRN) – applies to the Upper and Lower Klamath Basin.

General modeling assumptions in comparison to conditions considered for the Klamath Facilities Removal EIS/EIR water quality effects analyses are presented in Table D-2. As shown in Table D-2, for T1BSR, TOD2RN, and TCD2RN model runs, only Link River Dam was retained for the analysis. However, for these three model runs, the historically natural Keno Reef was included in place of Keno Dam, such that the Keno Reach is not characterized as a free-flowing river. For T4BSRN, Link River, Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate dams were retained for the analysis. Other modeling assumptions, limitations, and sources of uncertainty for the Klamath TMDL model are presented in Tetra Tech (2009a).

Table D-1. Numeric Models Used to Develop Water Quality Effects Determinations for the Proposed Action and Alternatives.

Reach	Water Quality Parameter					
	Water Temperature	Sediment and Turbidity	Dissolved Oxygen		Nutrients	pH
	Long-term[1]	Short-term[2]	Short-term[2]	Long-term[1]	Long-term[1]	Long-term[1]
No Action/No Project Alternative, Fish Passage at Four Dams Alternative						
Downstream of J.C. Boyle Reservoir (RM 224.7)	Klamath TMDL T4BSRN			Klamath TMDL T4BSRN	Klamath TMDL T4BSRN	Klamath TMDL T4BSRN
California-Oregon state line (RM 208.5)						
Downstream of Iron Gate Dam (RM 190.1)	Klamath TMDL T1BSR			Klamath TMDL T1BSR		
Shasta River (RM 176.7)						
Scott River (RM 143)	RBM10					
Seiad Valley (RM 129.4)						
Salmon River (RM 66)						
Trinity River (RM 40)						
Turwar (RM 5.8)						
Klamath River Estuary (RM 0-2)						
Proposed Action, Partial Facilities Removal of Four Dams Alternative						
Downstream of J.C. Boyle Reservoir (RM 224.7)	Klamath TMDL TOD2RN			Klamath TMDL TOD2RN	Klamath TMDL TOD2RN	Klamath TMDL TOD2RN
California-Oregon state line (RM 208.5)						
Downstream of Iron Gate Dam (RM 190.1)	Klamath TMDL TCD2RN	Reclamation SRH-1	Reclamation, USFWS, USGS, Stillwater Sciences BOD/IOD	Klamath TMDL TCD2RN	Klamath TMDL TCD2RN	Klamath TMDL TCD2RN
Shasta River (RM 176.7)						
Scott River (RM 143)	KRWQM[3]			KRWQM[3]		
Seiad Valley (RM 129.4)						
Salmon River (RM 66)	RBM10					
Trinity River (RM 40)						
Turwar (RM 5.8)						
Klamath River Estuary (RM 0-2)						

Table D-1. Numeric Models Used to Develop Water Quality Effects Determinations for the Proposed Action and Alternatives.

Reach	Water Quality Parameter					
	Water Temperature	Sediment and Turbidity	Dissolved Oxygen		Nutrients	pH
	Long-term[1]	Short-term[2]	Short-term[2]	Long-term[1]	Long-term[1]	Long-term[1]
Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative						
Downstream of J.C. Boyle Reservoir (RM 224.7)						
California-Oregon state line (RM 208.5)						
Downstream of Iron Gate Dam (RM 190.1)	KRWQM[3]			KRWQM[3]		
Shasta River (RM 176.7)						
Scott River (RM 143)	RBM10					
Seiad Valley (RM 129.4)						
Salmon River (RM 66)						
Trinity River (RM 40)						
Turwar (RM 5.8)						
Klamath River Estuary (RM 0-2)						

[1]Long-term – greater than 2 years following dam removal.

[2]Short-term – less than 2 years following dam removal.

[3]KRWQM results available for the mainstem immediately downstream of Iron Gate Dam, Scott River confluence, and Salmon River confluence (PacifiCorp 2004).

Key:

Klamath TMDL T4BSRN – with-dams Oregon and California TMDLs allocation scenario (Tetra Tech 2009b).

Klamath TMDL T1BSR – natural conditions baseline scenario for California TMDLs (Tetra Tech 2009b). The T1BSR natural conditions scenario is useful for analyzing those water quality parameters that rely on a comparison to background or natural levels for regulatory water quality standards, such as water temperature and dissolved oxygen.

Klamath TMDL TOD2RN – Oregon TMDLs allocation scenario (Tetra Tech 2009b).

Klamath TMDL TCD2RN – California TMDLs allocation scenario (Tetra Tech 2009b).

KRWQM – Klamath River Water Quality Model (Watercourse Engineering, Inc. 2003, PacifiCorp 2004).

RBM10 – water temperature model including climate change and BO and KBRA flows (Perry et al. 2011).

Reclamation SRH-1 – 1-dimensional sedimentation and river hydraulics model (Huang and Greimann 2010, Greimann et al. 2010).

BOD/IOD – biological oxygen demand (BOD)/immediate oxygen demand (IOD) spreadsheet model developed in collaboration with Reclamation, USGS, and USFWS (Stillwater Sciences 2011).

Table D-2. Comparison of Assumptions and Parameters for Available Numeric Models to Conditions Considered for Water Quality Effects Determinations for the Klamath Facilities Removal EIS/EIR.

Assumptions/Model Parameters	Available Numeric Models for Long-term Conditions: KRWQM	Available Numeric Models for Long-term Conditions: Klamath TMDL	Conditions Considered for Klamath Facilities Removal EIS/EIR: Proposed Action and Partial Facilities Removal of Four Dams Alt	Conditions Considered for Klamath Facilities Removal EIS/EIR: No Action/No Project Alt and Fish Passage at Four Dams Alt	Conditions Considered for Klamath Facilities Removal EIS/EIR: Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alt
Water quality constituents considered	• Water temperature [1] • Dissolved oxygen [1] • Nutrients • Chlorophyll-a	• Water temperature • Dissolved oxygen • Nutrients • pH • Chlorophyll-a	• Water temperature • Suspended material • Dissolved oxygen • Nutrients • pH • Chlorophyll-a • Algal toxins		
Dams remaining in-place	• "WOP" and "WOP2" = Link River • "WIGCJCB" = Link River and Keno • "WIGC" = Link River, Keno, J.C. Boyle • "WIG" = Link River, Keno, J.C. Boyle, Copco 1 and 2 • "EC" = Link River, Keno, J.C. Boyle, Copco 1 and 2, Iron Gate	• "T4BSRN" = Link River, Keno, J.C. Boyle, Copco 1 and 2, Iron Gate • "TOD2RN" and "TCD2RN" = Link River and Keno Reef [2] • "TIBSR" = Link River and Keno Reef [2]	• Link River • Keno	• Link River • Keno • J.C. Boyle • Copco 1 & 2 • Iron Gate	• Link River • Keno • J.C. Boyle
Flows	• Existing conditions for 2000–2004 [3] • NMFS Biological Opinion Mandatory Flows for the Klamath Project	• Existing conditions [4]	• KBRA • NMFS Biological Opinion Mandatory Flows (NMFS 2010)		
Reaches	Link River Dam (RM 253.7) to Turwar (RM 5.8)	Link River Dam (RM 253.7) to the Klamath River Estuary (RM 0–2)	Link River Dam (RM 253.7) to the Klamath River Estuary (RM 0–2)		
Analysis year(s)	2000–2004	2000	2020–2060		
Climate change	Not included	Not included	Considered semi-quantitatively using Bartholow (2005) and other available climate change literature		

Table D-2. Comparison of Assumptions and Parameters for Available Numeric Models to Conditions Considered for Water Quality Effects Determinations for the Klamath Facilities Removal EIS/EIR.

Assumptions/Model Parameters		Available Numeric Models for Long-term Conditions		Conditions Considered for Klamath Facilities Removal EIS/EIR		
		KRWQM	Klamath TMDL	Proposed Action and Partial Facilities Removal of Four Dams Alt	No Action/No Project Alt and Fish Passage at Four Dams Alt	Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alt
Nutrients	Upper Klamath Lake and inputs to Keno Impoundment	Existing conditions [5]	OR and CA full TMDL compliance [6]	Eventual OR and CA full TMDL compliance [6] Timescale assumed to be decades		
	Small tributaries to the lower Klamath River (i.e., Iron Gate Dam to Klamath Estuary)	• TN: 0.275 mg/L • TP: 0.075 mg/L	• TN: 0.077 mg/L [8] • TP: 0.014 mg/L [8]	N/A		
Algae and particulate organic matter (POM)	Upper Klamath Lake and inputs to Keno Impoundment	• Current conditions [4]	OR and CA full TMDL compliance [5]	• Eventual OR and CA full TMDL compliance[5] • Timescale assumed to be decades		
	Settling rates in all reservoirs	• Algal settling rate = 1.0 m/day [6] • POM = 0.5 m/day [7]	• Algal settling rate = 0.3 m/day [9] • POM = 0.8 m/day [9]	N/A		

[1] Published results available for water temperature and dissolved oxygen in PacifiCorp (2005). Additional results available in the FERC record and as an electronic appendix to http://www.riverbendsci.com/reports-and-publications-1/klam_wq_model_eval.pdf

[2] The historically natural Keno Reef was included in place of Keno Dam, such that the Keno Reach is not characterized as a free-flowing river.

[3] The WOP2 scenario has "smoothed flows" from Klamath Irrigation Project, to account for the fact that if Keno Dam were removed, Link releases would have to be smoothed due to instream flow requirements downstream.

[4] Exceptions to current conditions include the TIBSR model (natural conditions) where dramatically increased summer flows (i.e., no diversions) were assumed for tributaries to the mainstem Klamath River. Reclamation 2005 "un-depleted natural flows" were used for flows at Link River Dam and Keno Impoundment. For T4BSRN, TOD2RN, and TCD2RN, Shasta River flows are increased by 45cfs (Tetra Tech 2009a).

[5] Link Dam current conditions based on combination of individual samples and long-term monthly averages (used when individual samples not available) from Freemont Bridge (near outlet of Upper Klamath Lake, Link Dam, and Eastside/Westside powerhouses. Current conditions for other inputs to Keno Impoundment are based on combination of individual samples and averages.

[6] Full implementation assumes 80-90% reductions (relative to current conditions) for total nitrogen (TN), total phosphorus (TP), and biochemical oxygen demand (BOD) for the Lost River and Klamath Straits Drain inputs to Keno Impoundment and 90% TP reduction for wastewater treatment plant point sources (Kirk et al. 2010). The resulting decrease in nutrient loads at the California-Oregon state line is 87% for TP and 62% for TN and BOD (calculated from information in Table 2-8, Kirk et al. [2010]).

[7] PacifiCorp (2005).

[8] NCRWQCB (2010).

[9] Tetra Tech (2009a).

Lastly, the 1-dimensional RBM10 water temperature model was developed as part of the Secretarial Determination studies. The RBM10 model is well suited to the temporal, spatial, and structural requirements for simulating water temperatures in the Klamath Basin because it can 1) predict mean daily water temperature along a longitudinal gradient of a river, 2) accommodate both reservoir and river sections, and 3) simulate long time series (50 years) quickly (Perry et al. 2011). RBM10 was used to simulate water temperatures for 2012-2061 under two management alternatives ("BO" [Biological Opinion], which represents the No Action/No Project Alternative, and "KBRA", which represents the Proposed Action. RBM10 includes and six climate scenarios (i.e., 12 fifty-year simulations). The six future climate scenarios represent hydrology and meteorology using the "Index Sequential Method" and five alternative Global Circulation Models (GCMs; Greimann et al., 2010). The Index Sequential Method generates flows based on historical hydrology and meteorology under future operational conditions (Greimann et al. 2010)

As presented in Table D-2, major differences between the existing numeric models and the conditions considered for the Klamath Facilities Removal EIS/EIR water quality analyses include the following:

- The Klamath TMDL TOD2RN and TCD2RN ("dams out") model runs remove PacifiCorp dams and represent Keno Dam as the historical natural Keno Reef, such that the Keno Reach is not characterized as a free-flowing river. The KRWQM includes a model run retaining Keno. The Klamath Facilities Removal EIS/EIR analysis retains Keno Dam for the Proposed Action and all alternatives, based on the Project description.
- River flows for the Klamath Facilities Removal EIS/EIR analysis are based on Klamath Basin Restoration Agreement (KBRA) flows, which would tend to be greater than those modeled in either the Klamath TMDL model (with the exception of T1BSR) or the KRWQM (see Section 3.6, Flood Hydrology, for a summary of Klamath Basin Restoration Agreement components affecting hydrology on the Klamath River under the Proposed Action).
- Climate change was not considered in either the KRWQM or the Klamath TMDL model.
- The RBM10 water temperature model includes climate change projections and KBRA flows.

To place the Proposed Action analysis in the proper context, the above differences are generally considered as part of the water quality effects determinations whenever numeric model results are utilized.

Additionally, two models have been developed for the Secretarial Determination process to determine potential short-term impacts under the Proposed Action on suspended sediment and dissolved oxygen downstream of the dams. The first, a 1-dimensional sedimentation and river hydraulics model (SRH-1D), was developed to simulate existing conditions for hydraulics and sediment transport downstream of Iron Gate Dam as well as predict suspended sediment concentrations under multiple drawdown scenarios of the

Proposed Action. The SRH-1D model uses three "water year types" defined by the probability that in a given year the river could experience flows exceeding the low-level outlet capacities of the reservoirs (i.e., reservoir storage capacity at the level of the outlet that can evacuate the major portion of the reservoir storage volume by gravity flow)between March and June; a typical "dry year" is defined as having a 10 percent probability of exceedance (i.e., Water Year[1] [WY] 2001), a median year has a 50 percent probability of exceedance (i.e., WY 1976), and a typical wet year has a 90 percent probability of exceedance (i.e., WY 1984) (Greimann et al. 2010). Modeling assumptions, limitations and sources of uncertainty are presented in Huang and Greimann (2010) and Greimann et al. (2010).

The second model developed for the Secretarial Determination process is a simplified spreadsheet model used to investigate the potential influences that re-suspension of reservoir sediments may have on short-term dissolved oxygen levels downstream of Iron Gate Dam. Developed in collaboration with United States Bureau of Reclamation, United States Geological Survey and United States Fish and Wildlife Service, the model uses results from a combination of *in situ* sampling of reservoir sediments and water quality, and laboratory analysis of oxygen demand from the resuspended reservoir sediments, combined with numerical modeling of biochemical oxygen demand, immediate oxygen demand, sediment oxygen demand and oxygen demand as a function of suspended sediment concentrations and other variables. Modeling assumptions, limitations and sources of uncertainty are presented in Stillwater Sciences (2011).

D.2 Environmental Effects Determination Methodology for Short-term Suspended Sediments

NCRWQCB has developed the Desired Conditions Report (2006) as a guidance document describing sediment-related indices of importance to salmonid habitat conditions, including the application of the Newcombe and Jensen (1996) Severity Index and the Suspended Sediment Dose Index. The Severity Index provides a ranking of the effects of suspended sediment on salmonid species, while the Suspended Sediment Dose index relates salmonid exposure time to suspended sediment using a natural log relationship shown below:

Suspended Sediment Dose Index = ln (suspended sediment [mg/L] x exposure time [hrs])

The guidance document suggests that a Severity Index Rank of four or greater represents significant harm to salmonids so as to be detrimental to the beneficial use associated with cold freshwater habitat (NCRWQCB 2006). This ranking would equate to a suspended sediment concentration of 0.15 mg/L and a Suspended Sediment Dose Index of 4.6 (Table D-3 below), assuming 4 weeks exposure as a chronic condition that is likely to occur under a dam removal scenario. However, the general significance criteria adopted

[1] Water year is defined as October 1 to September 30.

for this analysis state that an impact must result in *substantial* adverse affects on beneficial uses of water to be considered significant. Thus, for the Klamath Facilities Removal EIS/EIR water quality analysis, a Severity Index Rank of 8.0 is considered to be a substantial impact, because it corresponds to "major physiological stress, poor condition, and/or long-term reduction in feeding rates" for exposed salmonids (Newcombe and Jensen 1996). This ranking would equate to a suspended sediment concentration of 30 mg/L and a Suspended Sediment Dose Index of 9.9, assuming 4 weeks exposure as a chronic condition (Table D-3). Within the uncertainty of the suspended sediment model developed by Reclamation, for which suspended sediment concentrations are predicted to within a factor of 2 (Greimann et al. 2010), impacts on salmonids could reasonably range from minor (Severity Index Rank of 4–5) to major (Severity Index Rank 8), but would not be expected to cause mortality (Severity Index Rank >10). Therefore, the water quality effects determination uses a predicted suspended sediment value of 30 mg/L over a 4-week exposure period as a general threshold of significance for analyzing the effects of the project alternatives.

Table D-3. Calculated Suspended Sediment Dose Index (SSDI) and Severity Index Rank for a Range of Suspended Sediment Concentrations (SSCs). Based on Newcombe and Jensen (1996).

SSC (mg/L)	SSDI[1]	Severity Index Rank
0.15	4.6	4.0
0.5	5.8	4.9
1	6.5	5.5
4	7.9	6.5
10	8.8	7.2
30	9.9	8.0
60	10.6	8.6
200	11.8	9.5
800	13.2	10.5
3,000	14.5	11.5
7,000	15.4	12.1

[1] Based on 4-week exposure period as a chronic condition.

A more detailed analysis of suspended sediment effects on key fish species, including consideration of specific life history stages, suspended sediment concentrations, and exposure period, is required for a comprehensive assessment of the impacts of the project alternatives on the cold water designated beneficial use. This level of analysis is presented in Section 3.3 Aquatic Resources and appendices to that section, including additional background regarding the applicability of the Newcombe and Jensen (1996) Severity Index Ranks and the Suspended Sediment Dose Index for key fish species in the lower Klamath River. Further discussion of particular effects of suspended sediment on shellfish and estuarine and marine organisms is also presented in Section 3.3.4.3 Aquatic Resources.

D.3 Environmental Effects Determination Methodology for Inorganic and Organic Contaminants

To date, the Secretarial Determination sediment evaluation process has followed screening protocols of the Sediment Evaluation Framework (SEF) for the Pacific Northwest, issued in 2009 by the interagency Regional Sediment Evaluation Team (RSET). The SEF is a regional guidance document that provides a framework for the assessment and characterization of freshwater and marine sediments in Idaho, Oregon, and Washington (RSET 2009). Level 2A of the SEF involves a data screening assessment to compare reservoir sediment data to available and appropriate sediment maximum levels (MLs), screening levels (SLs), and bioaccumulation triggers (BTs); and, Level 2B, including bioassays, bioaccumulation tests and special evaluations such as elutriate chemistry and risk assessments (CDM 2011).

The set of sediment MLs, SLs, and BTs included thus far in the Secretarial Determination process for Level 2A of the SEF represents an array of screening tools for different potential effects scenarios and are (briefly) the following:

- **Pacific Northwest SEF** sediment screening levels for standard chemicals of concern and chemicals of special occurrence in marine and freshwater bulk sediments for Idaho, Oregon, and Washington (RSET 2009)[2];
- **Dredged Material Management Program (DMMP)** screening levels (SL), bioaccumulation thresholds (BT), and maximum levels (MT) for marine sediments[3] in Puget Sound, Washington;
- **Screening Quick Reference Tables (SQuiRTs)** guideline values compiled by NOAA Fisheries, covering organic and inorganic contaminants in a variety of environmental media, including marine and freshwater sediments;
- **Oregon DEQ bioaccumulation screening level values (BSLVs)** for humans and relevant classes of wildlife (e.g., freshwater fish, birds, mammals);
- **California Human Health Screening Levels** are concentrations of hazardous chemicals in soil or soil gas that the California Environmental Protection Agency considers to be below thresholds of concern for risks to human health**;** and,
- **USEPA Regional Screening Levels** (formerly Preliminary Remediation Goals) for assessing human health long-term (i.e., 24-yr) exposure risk for contaminated soils and sediments in various settings (USEPA 1991, 1996, 2002).

Additional information regarding the screening levels is presented in CDM (2011), along with the compilation of screening level values. For the Secretarial Determination process, the sediment screening values have been used in a step-wise manner to

[2] Similar numeric chemical guidelines for the assessment and characterization of freshwater and marine sediments do not exist for California. The SWRCB is in the process of developing and adopting sediment quality objectives (SQOs) for enclosed bays and estuaries. However, the California SQOs are designed to assess in-place, surficial sediments as opposed to deeper sediment deposits or sediment discharges. As such, the California SQOs are not considered particularly relevant to the Secretarial Determination process or the EIS/EIR effects assessment.

[3] The DMMP guidelines do not include numeric values for freshwater sediments.

systematically consider potential impact pathways under each of the Project alternatives (or later, during subsequent permitting actions). The applicability of each of the screening levels to the EIS/EIR effects determination analysis varies depending on the project alternative (Table D-2).

Level 2B testing under the SEF consists of biological testing (bioassays or tissue analyses) or other special evaluations that are completed to provide more empirical evidence regarding the potential for sediment contamination to have adverse effects on receptors (RSET 2009). While tests involving whole sediment identify potential contamination that could affect bottom-dwelling (benthic) organisms, tests using suspension/elutriates of dredged material assess potential water column toxicity. For freshwater ecosystems that contain salmonid species, rainbow trout (*Oncorhynchus mykiss*) is recommended as one of the elutriate test species. A bioaccumulation evaluation is undertaken under SEF Level 2B when bioaccumulative chemicals of concern compared to screening levels either exceed or are inconclusive, and thus need further evaluation to determine if they pose a potential risk to human health or ecological health in the aquatic environment (RSET 2009).

Results from elutriate chemistry, sediment bioassays, and elutriate bioassays carried out for the Secretarial Determination studies are used to provide additional information beyond simple comparisons of sediment contaminant levels to regional or national screening levels (CDM 2011). Elutriate data is evaluated through comparison with a suite of regional, state and federal standards for water quality (Tables D-4 and D-5); the comparison is first carried out without consideration of dilution as a conservative approach. The results of sediment and elutriate bioassays are analyzed for acute toxicity potential for two benthic organisms (*Chironomus dilutus, Hyalella azteca*) and one freshwater fish (*Onchorhynchus mykiss*). *Chironomus dilutus* and *Hyalella azteca* are national "benchmark" toxicity indicator species, as identified in the joint USEPA–USACE Inland Testing Manual for the evaluation of dredged material proposed for discharge into waters of the United States, as follows:

Benchmark species comprise a substantial data base, represent the sensitive range of a variety of ecosystems, and provide comparable data on the relative sensitivity of local test species. Other species may be designated in future as benchmark species by USEPA and the US Army Corps of Engineers when data on their response to contaminants are adequate. Only benthic species should be tested. Although sediment dwellers are preferable, intimate contact with sediment is acceptable. Note that testing with all recommended taxa is not required; however, at least one [benchmark] amphipod taxon should be tested (USEPA and USACE 1998).

Table D-4. Applicable Screening Levels for Determination of Potential Toxicity and Bioaccumulation Effects from Sediment-Associated Contaminants Under the Proposed Action and Alternatives.

Screening Level	No Action/No Project	Full Facilities Removal (Proposed Action)	Partial Facilities Removal	Fish Passage at Four Dams	Fish Passage at Two Dams
Pacific Northwest Sediment Evaluation Framework (SEF)					
Marine (SL1, SL2)		X	X		X
Freshwater (SL2, SL2)	X	X	X	X	X
Puget Sound Dredged Materials Management Program (DMMP)					
Marine (SL, BT, ML)		X	X		X
SQuiRT Values					
Marine (ERL, ERM, T20, TEL, T50, PEL)		X	X		X
Freshwater (TEL, LEL, PEL, SEL, TEC, PEC)	X	X	X	X	X
Oregon DEQ Bioaccumulation Screening Level Values (BSLVs)					
Freshwater (Fish, Bird-Individual, Bird-Population, Mammal-Individual, Human-General, Human-Subsistence)	X	X	X	X	X
USEPA Regional Screening Levels (RSLs)					
Residential Soil Supporting (Total Carcinogenic, Total Non-carcinogenic)	X	X	X	X	X
California Human Health Screening Levels (CHHSLs)					
Residential Soil Supporting (Total Carcinogenic, Total Non-carcinogenic)	X	X	X	X	X

Screening Level Key:

SL1= Sediment Screening Level 1
SL2= Sediment Screening Level 2
SL= Screening Level
BT= Bioaccumulation Trigger
ML= Maximum Level
SQuiRTs= Screening Quick Reference Tables
ERL= Effects Range Low
ERM= Effects Range Median
T20= Chemical concentration representing a 20% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a.* and *Rhepoxynius a.*).
TEL= Threshold Effect Level
T50= Chemical concentration representing a 50% probability of observing an effect, calculated using individual chemical logistic regression models based on 10-day survival results from marine amphipod tests (*Ampelisca a.* and *Rhepoxynius a.*).
PEL= Probable Effect Level
LEL= Lowest Effect Level
SEL= Severe Effect Level
TEC= Threshold Effect Concentration
PEC= Probable Effect Concentration

Table D-5. Applicable Water Quality Criteria for Determination of Potential Toxicity and Bioaccumulation Effects from Sediment-Associated Contaminants Under the Proposed Action and Alternatives.

Water Quality Criteria	No Action/No Project	Full Facilities Removal (Proposed Action)	Partial Facilities Removal	Fish Passage at Four Dams	Fish Passage at Two Dams
NCRWQCB Basin Plan					
Freshwater (Aquatic Life CTR, Aquatic Life NTR)	X	X	X	X	X
Human Health (Primary MCL, Secondary MCL, Agriculture, Human Health CTR, Human Health NTR)	X	X	X	X	X
California Ocean Plan					
Marine (Aquatic Life Chronic, Aquatic Life Acute, Aquatic Life Instant)		X	X		X
Human Health (CAR, NCAR, Water and Organism)		X	X	X	X
CCR-California Department of Public Health					
Human Health (DLR, MCL)	X	X	X	X	X
Oregon DEQ Water Quality Criteria					
Freshwater (Acute, Chronic)	X	X	X	X	X
Human Health (Water and Organism, Organism only, Drinking Water)	X	X	X	X	X
Oregon DEQ Water Quality Guidance Values X					
Freshwater (Acute, Chronic)					X
National Regional Water Quality Criteria Priority Pollutants					
Freshwater (CMC, CCC)	X	X	X	X	X
Marine (CMC, CCC)		X	X		X
Human Health (Water and Organism, Organism Only)	X	X	X	X	X
National Regional Water Quality Criteria Non-priority Pollutants					
Freshwater (CMC, CCC)	X	X	X	X	X
Marine (CMC, CCC)		X	X		X
Human Health (Water and Organism, Organism Only)	X	X	X	X	X

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Appendix E
An Analysis of Potential Suspended Sediment Effects on Anadromous Fish in the Klamath Basin

E.1 Introduction

Removing the four dams in the mid-Klamath River (the "Proposed Action") could release up to 1.2-2.9 million metric tons of fine sediment (sand, silt, and finer) downstream (Bureau of Reclamation [Reclamation] 2011), resulting in high suspended sediment loads and local, short-term sediment deposition. The downstream transport of this sediment, currently stored in reservoir deposits, can affect downstream habitats as both suspended sediment and bedload. Among other impacts, elevated suspended sediment concentrations (SSC) may clog or abrade the gills of fish or prevent them from foraging efficiently, and as the material settles on the streambed, it can reduce the survival of incubating eggs and developing alevins in salmonid redds by impeding intergravel flow as well as the emergence of fry.

This report describes a modeling analysis of the potential effects of suspended sediment on anadromous fish populations in the Klamath Basin under existing conditions and the No Action/No Project Alternative, as well as under the Proposed Action. Available data on suspended sediment under existing conditions in the Klamath River upstream and downstream of Iron Gate Dam (summarized in Section 3.2.3, Water Quality – Existing Conditions/Affected Environment) were determined to be insufficient for conducting this type of analysis. To compensate for this shortfall, the Reclamation used suspended sediment data collected by the United States Geological Survey at the (1) Shasta River near Yreka, (2) Klamath River near Orleans, and (3) Klamath River at Klamath gauges to estimate daily suspended sediment concentrations (milligrams per liter [mg/l]) as a function of flow (cfs) using the SRH-1D 2.4 sediment transport model (Sedimentation and River Hydraulics–One Dimension Version 2.4) (Huang and Greimann 2010, USBR 2011), hereafter referred to as "the model." Daily SSC were modeled for water years 1961 through 2008 to represent existing conditions and the No Action/No Project Alternative, as well as for the year following removal of the dams (Water Year 2020-2021) under multiple drawdown scenarios (Reclamation 2011).

E.2 Methods

The analysis of the potential effects of suspended sediment on aquatic species in the Klamath River followed a five-step process similar to that used in prior modeling of these effects conducted by Stillwater Sciences (2008, 2009a, 2009b):

1. Select appropriate focal species for the analysis;

2. Use the model to predict SSC regimes for existing conditions and the No Action/No Project Alternative, and alternatives;

3. Describe the potential effects of the predicted concentrations on the various life stages of each focal species using available information; and

4. Evaluate the potential consequences of suspended sediment for focal species' populations under existing conditions and the No Action/No Project Alternative, and alternatives.

E.2.1 Focal Species Selection

Focal species selected for the analysis were expected to meet the following criteria:

1. Species historically native to, and still found within the Klamath Basin downstream of Iron Gate Dam, and within the area of primary effect (i.e., upstream of the confluence with Trinity River);

2. Species that are listed or proposed for listing under the Federal or State Endangered Species Acts, or

3. Species without special regulatory status that meet other criteria, such as: species having high economic or public interest value, species believed to be important interactors within the affected ecosystem ("key species"), species believed to be strong indicators of the overall health of aquatic communities ("indicator species"), or those whose presence is believed to reflect habitat conditions for a large suite of species ("umbrella species"); and

4. Species for which sufficient information is available to allow at least a qualitative assessment of their response to increases in suspended sediment.

Based on this vetting process, the following focal species were selected for the suspended sediment analysis:

- Chinook salmon (fall- and spring-runs)
- coho salmon
- steelhead (summer and fall/winter runs)
- Pacific lamprey
- green sturgeon

E.2.2 Using the Model to Predict Suspended Sediment Concentrations

Predictions of suspended sediment concentrations used in this analysis were based on the sediment transport model, which:

1. Predicts SSC as a continuous time series following facility removal;
2. Predicts the exceedance duration (number of consecutive days) for specific SSC ranges within time periods corresponding to specific life-history stages of the focal species (such as upstream migration); and,
3. Predicts the downstream dilution of SSC at important locations within the distributions of the focal species where gauging data are available, including Iron Gate Dam, Seiad Valley, Orleans, and Klamath Station.

The model was used to predict the magnitude and duration of suspended sediment concentrations for discrete calendar-year periods corresponding to each species' life history stages. These periods could not overlap in order to avoid erroneously accounting for an event's impact on two separate life stages of a cohort at the same time, which is impossible; e.g., a pulse of suspended sediment in March cannot simultaneously affect rearing juveniles and outmigrating smolts of the same cohort.

E.2.2.1 Range of Conditions Assessed

Modeling results are very sensitive to hydrology. Effects during winter are predicted to be more severe during a dry year when low reservoir levels expose more sediment in January. Effects during spring (when smolt outmigration generally occurs) are more severe during a wet year, when it is predicted that the reservoirs could re-fill during winter delaying the release of SSC until they drop during spring (Reclamation 2011). Daily durations of SSC concentrations were modeled assuming the Proposed Action occurred within each of the 48 years in the available hydrology record since 1961. The results of modeling all potential years were summarized for each life-stage of each species assessed. Because the suspended sediment varies with hydrology, and in order to account for (and compare) the range of results and impacts that might occur under each alternative, two scenarios were analyzed for existing conditions and the No Action/No Project Alternative, and for action alternatives, with the goal of predicting the potential impacts to fish that has either a 50 percent (likely to occur) or 10 percent (unlikely, or worst case) probability of occurring, defined as follows:

For Existing Conditions and the No Action/No Project Alternative:

- **Normal conditions:** suspended sediment concentrations and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream of Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any one year is 50 percent). Exceedance probabilities were based on modeling SSC for all water years subsequent to 1961 with facilities in place. To assess "normal conditions" the median (50 percent) suspended sediment concentration and duration from these results was estimated.

- **Extreme conditions:** suspended sediment concentrations and durations with a 10 percent exceedance probability; i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any 1 year is 10 percent).

For the Proposed Action– Full Facilities Removal of Four Dams:

- **Most likely scenario:** suspended sediment concentrations and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream of Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any one year is 50 percent). Exceedance probabilities were based on the results of modeling suspended sediment in the Klamath River downstream of Iron Gate Dam using hydrologic data for all water years observed since 1961 with facility removal. To assess the "most likely scenario" the median (50 percent exposure concentration) was estimated.

- **Worst-case scenario:** suspended sediment concentrations and durations with a 10 percent exceedance probability; i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any 1 year is 10 percent).

E.2.3 Effects Analysis

Based on a review of the scientific literature, the most commonly observed effects of suspended sediment on salmonids include: (1) avoidance of turbid waters in homing adult anadromous salmonids, (2) avoidance or alarm reactions by juvenile salmonids, (3) displacement of juvenile salmonids, (4) reduced feeding and growth, (5) physiological stress and respiratory impairment, (6) damage to gills, (7) reduced tolerance to disease and toxicants, (8) reduced survival, and (9) direct mortality (Newcombe and Jensen 1996). Information on both concentration and duration of suspended sediment is necessary for understanding the potential severity of its effects on salmonids (Newcombe and MacDonald 1991); e.g., Herbert and Merkens (1961) stated that "there is no doubt that many species of fresh-water fish can withstand extremely high concentrations of suspended solids for short periods, but this does not mean that much lower concentrations are harmless to fish which remain in contact with them for a very long time." Effects of suspended sediment on fish may be exacerbated if pollutants or other stressors (e.g., water temperature, disease) are present as well. Turbidity can function as cover to reduce predation at some life stages, not only in riverine, but also in estuary and nearshore marine environments (Gregory and Levings 1998, Wilber and Clarke 2001, Gadomski and Parsley 2005). Some species have been shown to be attracted to turbid water over clear, which may reflect its use as cover (Gradall and Swenson 1982, Cyrus and Blaber 1992, both as cited in Wilber and Clarke 2001). This analysis will consider these other factors qualitatively, but not quantitatively, in assessing the effects of a sediment pulse to the population.

Determining the concentrations that cause direct lethal effects in salmonids has generally been based on laboratory studies experimenting with exposures to concentrations of suspended sediment over 1,000 mg/l and usually much higher. According to Sigler et al. (1984), "yearling and older salmonids can survive high concentrations of suspended sediment for considerable periods, and acute lethal effects generally occur only if concentrations exceed 20,000 ppm (see e.g., review by Cordone and Kelly 1961)." At very high concentrations (e.g., 20,000 to 30,000 mg/l), juvenile salmon may survive short-term exposures, but their survival may be subsequently affected by slower response times for seeking cover and avoiding predators (Korstrom and Birtwell 2006). Based on the results of laboratory studies, it appears that relatively short-term exposures to increases in suspended sediment concentrations under 500–600 mg/l would not likely result in substantial direct mortality to either juvenile or adult anadromous salmonids in the Klamath River. If the duration of exposure is extended for weeks or months, however, direct mortality (10–20 percent of individuals exposed) is expected (Newcombe and Jensen 1996).

Potential population-level effects of suspended sediment released from dam removal activities for a given species not only depend on their abundance, distribution, and life stages present, but also on the timing, duration, and concentration of suspended sediment released. In this analysis the results of Newcombe and Jensen (1996) were used to assess impacts of SSC on aquatic species. Newcombe and Jensen (1996) reviewed and synthesized 80 published reports of fish responses to suspended sediment in streams and estuaries and established a set of equations to calculate "severity of ill effect" indices (Table E-1) for various species and life stages based on the duration of exposure and concentration of suspended sediment present. The severity of ill effects provides a ranking of the effects of SSC on salmonid species, as calculated by any of six equations that address various taxonomic groups of fishes, life stages of species within those groups, and particle sizes of suspended sediments.

Assessing the potential effects of suspended sediment on anadromous fish species required identifying the spatial and temporal distribution of each life stage in the Klamath Basin relative to expected areas of elevated suspended sediment. For each focal species and life stage, potential effects were determined by evaluating the magnitude and duration of SSC predicted by the model for the mainstem Klamath River at times and locations where the life stage of any focal species is likely to be present. For salmonids, Newcombe and Jensen's (1996) Severity of Ill Effects table (Table E-1) was used to rate the severity of exposure to suspended sediment. The values for suspended sediment concentrations were divided into ranges (33–90 mg/l, 90–245 mg/l, 245–685 mg/l, and so on) based on those used in Newcombe and Jensen (1996). Wherever possible, effects were quantified based on the percentage of the cohort predicted be in the mainstem during suspended sediment events, considering both spatial distribution (proportion of the life stage expected to be in the mainstem compared to tributaries; proximity to Iron Gate

Dam) and life-history timing (proportion of the population expected to be present during period of effect).

Table E-1. Scale of the Severity of Ill Effects Associated with Elevated Suspended Sediment (based on Newcombe and Jensen 1996).

Severity	Category of Effect	Description of Effect
0	Nil effect	No behavioral effects
1	Behavioral effects	Alarm reaction
2		Abandonment of cover
3		Avoidance response
4	Sublethal effects	Short-term reduction in feeding rates Short-term reduction in feeding success
5		Minor physiological stress: Increase in rate of coughing Increased respiration rate
6		Moderate physiological stress
7		Moderate habitat degradation Impaired homing
8		Indications of major physiological stress: Long-term reduction in feeding rate Long-term reduction in feeding success Poor condition
9	Lethal effects	Reduced growth rate: Delayed hatching Reduced fish density
10		0–20% mortality Increased predation of effected fish
11		>20–40% mortality
12		>40–60% mortality
13		>60–80% mortality
14		>80–100% mortality

The indices used by Newcombe and Jensen (1996) have become a standard for selecting management-related turbidity and suspended sediment criteria (e.g., Walters et al. 2001), and their report remains the best available source for determining effects of SSC on salmonids (Berry et al. 2003). However, there are inherent sources of uncertainty in this application of the model. Newcombe and Jensen (1996) base much of their analysis on laboratory studies that were conducted in controlled environments over short-durations, mostly examining acute lethal impacts of non-fluctuating concentrations of suspended sediment. This analysis is a relatively complex application of the Newcombe and Jensen (1996) model, in that temporal variation in SSC within periods is captured by summing continuous days of exposure in various concentration categories of suspended sediment. This means that three occurrences of exposure to extreme sediment each lasting for two days can be, for example, equivalent to a severity of ill effect predicted for 6 continuous days. How the actual outcome will vary from predictions is uncertain. In addition, Newcombe and Jensen (1996) do not explicitly address the translation of sublethal severity levels into population-level effects. As Gregory et al. (1993) note in their criticism of Newcombe and Jensen, the approach simplifies the effects of suspended sediment and in doing so assumes all effects of suspended sediment are negative, despite literature to the contrary. This exaggerates the effects of suspended sediment, particularly for lower concentrations and durations of exposure. Although the predictions of mortality at high concentrations and durations of exposure are considered more certain than the predictions of sublethal effects, in this application sublethal effects resulting from exposure to lower concentrations are included because of the concern that following sublethal impacts of suspended sediment could be adverse when occurring in conjunction with the already stressed condition of some species and life-stages from water temperature (Bozek and Young 1994) and disease.

Because of their relative importance within the watershed, potential impacts of SSC on Pacific lamprey (*Lampetra tridentata*) and green sturgeon (*Acipenser medirostris*) were assessed. However, little scientific literature exists regarding the effects of SSC on these species. The models developed by Newcombe and Jensen (1996) for assessing impacts to nonsalmonids were used in this analysis to assess effects on Pacific lamprey and green sturgeon, in conjunction with discussions with experts regarding the potential effects.

E.3 Results

E.3.1 Existing Conditions and No Action/No Project Alternative

Information on sediment transport within the Klamath Basin is available from Stillwater Sciences 2010 and USBR 2011. The current supply of coarse and fine sediment can be summarized, as follows:

- Upstream of Keno Dam, sediment supply to the Klamath River is minimal due to deposition in Upper Klamath Lake, which captures nearly all sediment entering from its tributaries.
- Between Keno Dam and Iron Gate Dam, total average annual sediment delivery is an estimated 200,000 tons/year.
- Downstream of Iron Gate Dam, the Scott, Salmon, and Trinity Rivers supply approximately 607,000 tons/year; 320,000 tons/year; and 3.3 million tons/year, respectively.

Section 3.2.3 (Water Quality – Existing Conditions/Affected Environment) summarized suspended sediment concentrations under existing conditions in the Klamath River upstream and downstream of Iron Gate Dam. In general, the data indicate that suspended sediment downstream of Iron Gate Dam ranges from less than 5 mg/l during summer low flows to greater than 5,000 mg/l during winter high flows (Section 3.2.3.3). Daily SSC were modeled for water years 1961–2008 (Reclamation 2011) (Figures E-1 and E-2).

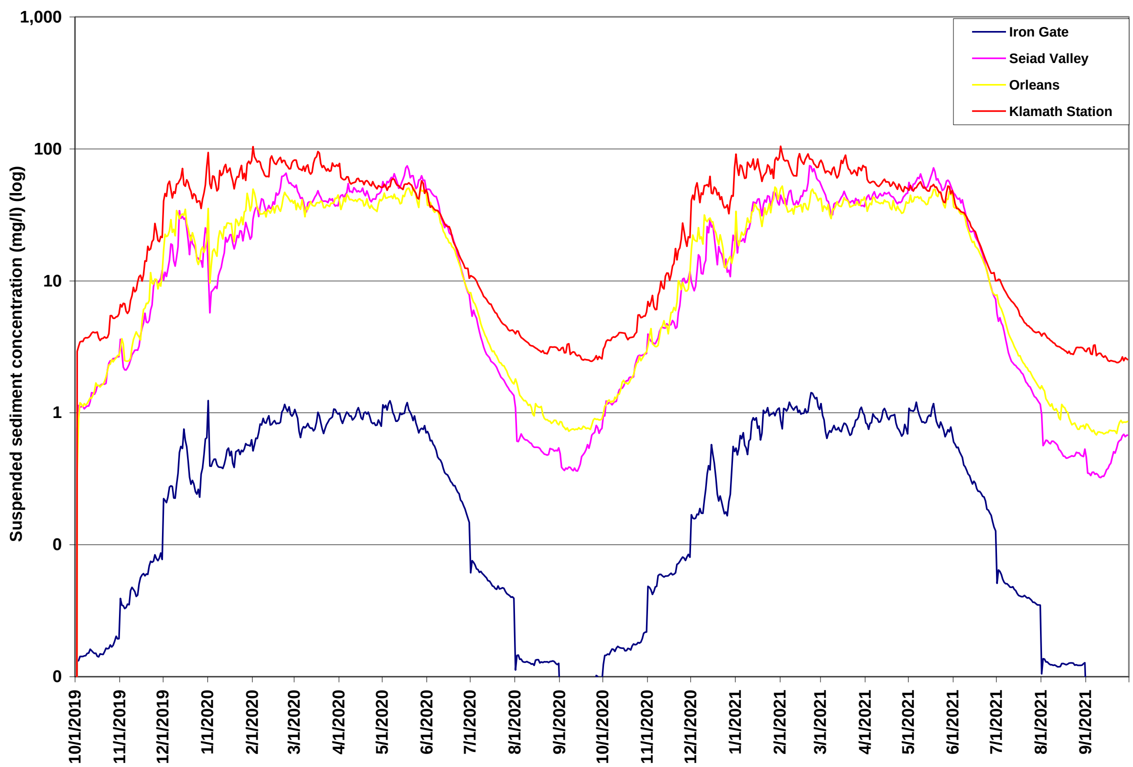

Figure E-1. Normal Conditions (50% exceedance probability) Suspended Sediment Concentrations at Three Locations Downstream of Iron Gate Dam under Existing Conditions, as predicted using the SRH-1D model.

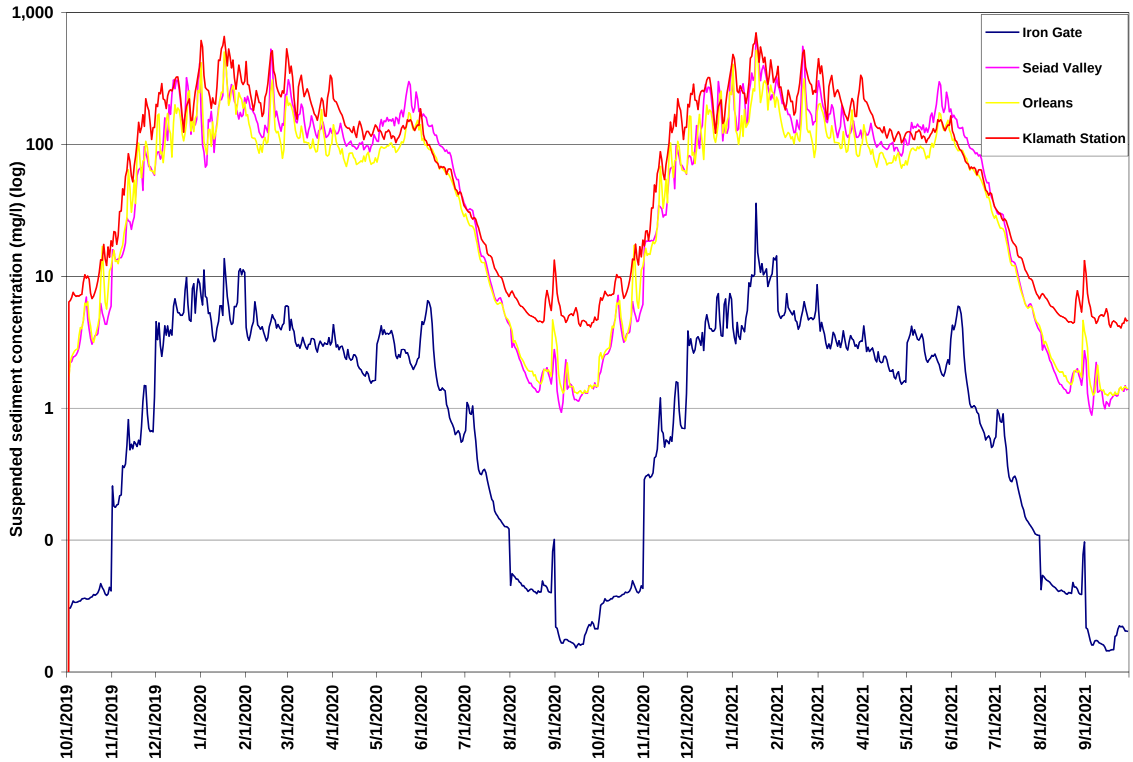

Figure E-2. Extreme Conditions (10% exceedance probability) Suspended Sediment Concentrations at Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted using the SRH-1D Model.

E.3.1.1 Fall-run Chinook Salmon

Fall-run Chinook salmon range throughout the Klamath River and its tributaries downstream of Iron Gate Dam. The largest number of spawners are found in the Trinity River (36 percent), Bogus Creek (11 percent), Shasta River (7 percent), Scott River (7 percent), and the Salmon River (3 percent), based on escapement data collected from 1978 to 2002 (FERC 2006). They also spawn in the mainstem, with the highest densities of redds found between Iron Gate Dam (River Mile [RM] 310.3) and the Shasta River (RM 288) (Magneson 2006).

Fall-run Chinook salmon in the Klamath Basin exhibit three juvenile life-history types: Type I (ocean entry at age 0[1] in early spring within a few months of emergence), Type II (ocean entry at age 0 in fall or early winter), and Type III (ocean entry at age 1 in spring) (Sullivan 1989). Based on outmigrant trapping at Big Bar on the Klamath River from 1997 to 2000, 63 percent of natural Chinook salmon outmigrants are Type I, 37 percent are Type II, and less than 1 percent are Type III (Scheiff et al. 2001). Although, trapping efforts are not equal among seasons, the results are consistent with scale analysis of adult

[1] A fish emerging in spring is designated as age 0 until January 1st of the following year, when it is designated as age 1 until January 1st of the next year, when it is designated age 2.

returns by Sullivan (1989). Large numbers of fry from the Shasta River, Scott River, and Hunter and Blue creeks move into the mainstem Klamath River in spring, where they may continue to rear before outmigrating to the ocean (Chesney 2000, Chesney and Yokel 2003). Few age-0 juveniles are observed in the mainstem Klamath River or Trinity River in the fall; most have probably already outmigrated in early fall as Type II smolts.

Fall Chinook salmon typically migrate upstream in late summer and early fall when suspended sediment concentrations are usually very low in the Klamath River. Spawning typically peaks in late October and substantially declines by the end of November (Shaw et al. 1997). The SRH-1D SSC modeling analysis does not account for stress or mortality that might result from infiltration of fine sediment into the channel bed because no suitable measurements or models were available with which to calculate this component. Under normal conditions, suspended sediment is predicted to result in minimal stress on spawning adults, eggs, alevins, and fry in the mainstem because of sediment capture by the dams and time of year (Table E-2), but may cause reduced size at emergence under extreme conditions (Table E-3) as well as further downstream where concentrations would be expected to be higher due to accretion from tributary streams.

Most fry produced by fall-run Chinook salmon in the Klamath River exhibit the Type I life history, in which they enter the ocean within a few months of emergence in early spring. Age 0 fry rearing in the mainstem during late winter for a period of a month prior to outmigration are anticipated to have moderate to major physiological stress under normal and extreme conditions respectively. Using radio-tag data, Foott et al. (2009) reported that it took hatchery Chinook smolts a median of 10.2 days to travel the 184 miles from Iron Gate Dam to Blake's Riffle (RM 8). Wallace (2004) reported that it took radio-tagged hatchery Chinook smolts a median of 30–34 days (range 13–109 days) to travel from the hatchery to the estuary. Based on these studies, the analysis assumed a maximum duration of exposure to suspended sediment during migration of 30 days. In a normal year under existing conditions and the No Action/No Project Alternative, suspended sediment in the mainstem is predicted to be at concentrations resulting in major physiological stress for Type I fry during their 30-day migration. In either scenario, this exposure, although not predicted to result in direct mortality, could indirectly affect survival by reducing growth and thus the size at which the smolts enter the ocean (Bilton 1984). Exposure to disease or elevated temperatures in the mainstem would likely result in the mortality of some portion of these fish. The parr-smolt transformation can also be compromised in stressed juveniles (Wedemeyer and McLeay 1981, as cited in Bash et al. 2001), which could increase mortality.

Table E-2. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Fall-Run Chinook Salmon under Normal Conditions (50% exceedance probability), for Klamath River at Iron Gate Dam (adult migration, spawning, incubation, and fry emergence life stages) and Seiad Valley (juvenile rearing and outmigration life stages).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Jul 15–Oct 31)	0	0	0	No effect
Spawning, incubation, and fry emergence (Oct 15–Feb 28)	0	0	0	~8 % of adults spawn in the mainstem downstream of Iron Gate Dam where suspended sediment is low due to capture of sediment by Iron Gate Dam
Juvenile rearing (year-round)	245 to 665	2	8	Major stress
	90 to 245	9	8	
	33 to 90	22	8	
Type I outmigration (Apr 1–Aug 31)	90 to 245	5	8	Major stress for Type I fry (~60% of all production)
	33 to 90	17	8	
Type II outmigration (Sept 1–Nov 30)	0	0	0	No effect
Type III outmigration (Feb 1–Apr 15)	245 to 665	<1	7	Moderate to major stress for Type III (yearling) outmigrants (<1% of production)
	90 to 245	4	8	
	33 to 90	11	8	

Table E-3. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Fall-Run Chinook Salmon under Extreme Conditions (10% exceedance probability), for Klamath River at Iron Gate Dam (adult migration, spawning, incubation, and fry emergence life stages) and Seiad Valley (juvenile rearing and outmigration life stages).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Jul 15–Oct 31)	0	0	0	No effect
Spawning, incubation, and fry emergence (Oct 15–Feb 28)	33 to 90	2	9	~8 % of adults spawn in the mainstem downstream of Iron Gate Dam where suspended sediment is low due to capture of sediment by Iron Gate Dam
Juvenile rearing (year-round)	1,808 to 4,915	1	9	Major stress, reduced growth, and up to 20% mortality for age 1 rearing in the mainstem.
	665 to 1,808	2	8	
	245 to 665	7	9	
	90 to 245	25	9	
	33 to 90	39	9	
Type I outmigration (Apr 1–Aug 31)	245 to 665	5	8	Major stress and reduced growth for Type I fry (~60% of all production).
	90 to 245	20	9	
	33 to 90	30	8	
Type II outmigration (Sept 1–Nov 30)	245 to 665	1	7	Short-term (1 wk) moderate stress.
	90 to 245	1	7	
	33 to 90	5	7	
Type III outmigration (Feb 1–Apr 15)	665 to 1,808	2	8	Major stress for Type III (yearling) outmigrants (<1% of production).
	245 to 665	4	8	
	90 to 245	14	8	
	33 to 90	27	8	

The Type II life history is also common among Klamath River fall-run Chinook. These juveniles remain to rear in the tributaries in which they were spawned (Section 3.3.3.1) and are only exposed to suspended sediment in the mainstem on their outmigration to the ocean in the fall, when SSC are lowest. In a normal year under existing conditions and the No Action/No Project Alternative, no adverse effects of suspended sediment are predicted for these fish, while in a year of extreme conditions, concentrations may cause avoidance, reduced feeding, and moderate physiological stress for approximately one week. Additional factors such as disease or elevated temperatures in the lower Klamath River are less likely to increase the impacts of suspended sediment on these fish than for other life-history types, because neither disease or water temperature are problems in the Klamath River mainstem during the fall when Type II smolts outmigrate.

Type III life-history fish are relatively rare (<1 percent of all production) in the Klamath River fall-run population (USFWS 2001), although based on Sullivan (1989) these larger smolts can contribute around 4 percent of the escapement. These fish typically remain to rear in the spawning tributaries until outmigrating in late winter and early spring as yearlings. In a normal year, the model predicts that suspended sediment will cause moderate to major physiological stress for about two weeks, but under extreme conditions, exposure to suspended sediment is predicted to remain at levels producing major stress for the approximately one month it takes for them to reach the sea, but growth may not be substantially affected.

Overall, fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Although SSCs under existing conditions and the No Action/No Project Alternative are relatively high in the mainstem downstream of Orleans, and even more so downstream of the Trinity River (State Water Resource Control Board [SWRCB] 2006, North Coast Regional Water Quality Control Board [NCRWQCB] 2010) (Section 3.2.3), they are relatively low in the reach downstream of Iron Gate Dam where most mainstem spawning occurs. Suspended sediment concentrations and durations during upstream and downstream migration, even under extreme conditions, are low enough that effects are limited to physiological stress and possibly reduced growth rates. In general, fall-run Chinook salmon appear relatively resilient to current suspended sediment conditions because of their limited use of the mainstem for spawning and rearing, and the fact that smolt outmigration primarily occurs when SSC are naturally low.

E.3.1.2 Spring-run Chinook Salmon

Spring-run Chinook salmon spawn primarily in the Salmon and Trinity rivers, with the vast majority (~95 percent) spawning in the Trinity River; therefore, the review of existing conditions and the No Action/No Project Alternative focuses on potential exposure to suspended sediment in the mainstem Klamath River downstream of the Salmon River.

Sediment-transport model predictions for suspended sediment and associated effects on spring-run Chinook salmon under normal and extreme conditions are summarized in Table E-4 and E-5, respectively. Under normal conditions, adult spring-run migrants returning to the Salmon River may be exposed to suspended sediment concentrations that cause moderate stress and impaired homing, but because the span of elevated concentrations is only around two weeks, some migrants may avoid exposure altogether. Under extreme conditions, concentrations may increase slightly, but the duration of exposure may double. Adults migrating to the Trinity River may only be exposed to suspended sediment in the mainstem for about a week, and those migrating to the Salmon River about two weeks (Strange 2007a, 2007b, 2008).

Table E-4. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Spring-Run Chinook Salmon under Normal Conditions (50% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult spring migration (Apr 1–June 30)[a]	90 to 245	2	7	Impaired homing for adults returning to Salmon River. Majority (~95% on average) of adults enter Trinity River, and will be exposed to higher concentrations for shorter durations. However, up to 35% of "natural" escapement returns to Salmon River.
	33 to 90	14	7	
Adult summer migration (Jul 1–Aug 31)[b]	0	0	0	No effect to the ~50% of the summer migration returning exclusively to the Trinity River.
Spawning, incubation, and fry emergence (Sept 1–Feb 28)	n/a	n/a	n/a	Spring-run do not generally spawn in the mainstem.
Juvenile rearing (variable)	n/a	n/a	n/a	Juveniles primarily rear in tributaries; no effect is anticipated.
Type I outmigration (Apr 1–May 31)[c]	90 to 245	2	7	Major stress for Type I fry (~80% of production) in smolt outmigration from Salmon River. Majority (~95%) of juveniles outmigrate from Trinity River, and are exposed to higher concentrations
	33 to 90	18	8	
Type II outmigration (Oct 1–Nov 15)[c]	0	0	0	No effect for Type II smolts from the Salmon River (~20 percent) during downstream migration. Majority (~95%) of juveniles outmigrate from Trinity River and are exposed to higher concentrations.
Type III outmigration (Jan 15–May 31)[c]	245 to 665	<1	7	Major stress for Type III fry from Salmon River (<1%) during downstream migration. Majority (~95 %) of juveniles outmigrate from Trinity River and are exposed to higher concentrations for shorter durations. Outmigrate from Trinity River and are exposed to higher concentrations for shorter durations.
	90 to 245	5	8	
	33 to 90	20	8	

a Maximum duration of exposure during migration = 14 days
b Maximum duration of exposure during migration = 2 days
c Maximum duration of exposure during migration = 30 days

Table E-5. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Spring-Run Chinook Salmon under Extreme Conditions (10% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult spring migration (Apr 1–June 30)[a]	245 to 665	<1	7	Impaired homing and major stress for adults returning to Salmon River. Majority (~95% on average) of adults enter Trinity River, and will be exposed to higher concentrations for shorter durations. However, up to 35% of “natural” escapement returns to Salmon River.
	90 to 245	14	8	
	33 to 90	14	7	
Adult summer migration (Jul 1–Aug 31)[b]	33 to 90	<1	6	Moderate stress for the ~50% of the summer migration returning exclusively to the Trinity River.
Spawning, incubation, fry emergence (Sept 1–Feb 28)	n/a	n/a	n/a	Spring-run do not generally spawn in the mainstem.
Juvenile rearing (variable)	n/a	n/a	n/a	Juveniles primarily rear in tributaries; no effect to this life stage is anticipated.
Type I outmigration (Apr 1–May 31)	90 to 245	12	8	Major stress for Type I fry (~80%) in smolt outmigration from Salmon River. Majority (~95 %) of juveniles outmigrate from Trinity River, and are exposed to higher concentrations.
	33 to 90	30	8	
Type II outmigration (Oct 1–Nov 15)[c]	90 to 245	1	7	Moderate stress for Type II smolts from the Salmon River (~20%) during downstream migration. Majority (~95 %) of juveniles outmigrate from Trinity River and are exposed to higher concentrations.
	33 to 90	2	6	
Type III outmigration (Jan 15–May 31)[c]	665 to 1,808	1	8	Major stress for Type III fry from Salmon River (<1%) during downstream migration. Majority (~95%) of juveniles outmigrate from Trinity River and are exposed to higher concentrations.
	245 to 665	5	8	
	90 to 245	13	8	
	33 to 90	30	8	

a Maximum duration of exposure during migration = 14 days
b Maximum duration of exposure during migration = 2 days
c Duration of exposure during migration = 30 days

In some years, later-arriving adults have been observed to delay migration upon encountering high water temperatures in the mainstem (>22°C) and hold in the river for up to 30 days before continuing on to their spawning streams (Strange 2007a, 2007b, 2008). These fish could be exposed to elevated suspended sediment for longer durations, particularly in extreme years. Stressed adults are assumed to be more susceptible to disease, possibly increasing pre-spawn mortality, unless exposure causes avoidance behavior and early entrance into tributary habitat as was observed for upstream-migrating

Chinook and coho salmon (*Oncorhynchus kisutch*) adults during the September 2002 fish kill in the lower Klamath River (M. Belchik, Fisheries Biologist, Yurok Tribe, pers. comm., 2008). Among radio-tagged adult spring Chinook, these later-returning migrants have been observed to have the highest mortality rates (Strange 2007a, 2007b, 2008). In contrast, around half of the observed spring Chinook salmon adults make a relatively rapid summer migration (~2 days in the Klamath River) to the Trinity River, at which time of year suspended sediment is naturally low under both normal and extreme conditions.

Since no spring-run Chinook salmon spawning occurs in the mainstem Klamath River under existing conditions and the No Action/No Project Alternative, incubating eggs, developing alevins, and emergent fry are not anticipated to be affected by suspended sediment in the mainstem).

There appear to be three juvenile life-history types for spring-run Chinook salmon in the Klamath Basin: Type I (ocean entry at age 0 in early spring within a few months of emergence), Type II (ocean entry at age 0 in fall or early winter [Olson 1996]), and Type III (ocean entry at age 1 in spring) (Sullivan 1989). Based on outmigrant trapping in the Salmon River from 2001 to 2006 (Karuk Tribe, unpubl. data), around 80 percent of outmigrants are Type I, 20 percent are Type II, and less than 1 percent are Type III. Rearing of age-0 juveniles likely occurs to some extent in the mainstem Klamath River, although it appears that the majority remain to rear in their natal streams (i.e., Salmon and Trinity rivers). It is unclear to what extent juvenile spring-run Chinook rear in the mainstem Trinity and Klamath Rivers as trapping studies do not differentiate between the spring and fall runs.

Most late-winter rearing of Type I and II juveniles is thought to occur in tributaries (West 1991; Dean 1994, 1995), reducing the likelihood of exposure to suspended sediment in the mainstem. Type I juveniles migrate downstream to the mainstem and ocean in April and May. Based on radio-tagging studies of Chinook salmon smolt travel times, a maximum of 30 days is assumed for exposure of outmigrating smolts. Under both normal and extreme conditions, exposure to suspended sediment during Type I smolt outmigration is anticipated to result in major physiological stress. This exposure, in association with other environmental factors in the basin (e.g., water temperatures, exposure to disease), could lead to mortality or reduced fitness. The Type II outmigration pattern is common (~20 percent),with juveniles departing from the Salmon River in the fall when suspended sediment downstream of the Salmon River is too low to have an effect under normal conditions, and only slightly higher under extreme conditions when concentrations may cause moderate physiological stress for a few days. Age-1 juveniles of the Type III life history outmigrating during winter and early spring may be exposed to suspended sediment concentrations causing major physiological stress under both normal and extreme conditions.

E.3.1.3 Coho Salmon

In order to evaluate the affects of suspended sediment on coho salmon in the Klamath River, the historical population structure of Southern Oregon Northern California Coast coho salmon presented in Williams et al. (2006) was used, as described in Section 3.3.3.1. Williams et al. (2006) identifies nine populations within the Klamath River, including the Upper Klamath River, Shasta River, Scott River, Salmon River, Mid-Klamath River, Lower Klamath River, and three population units within the Trinity River watershed (Upper Trinity River, Lower Trinity River, and South Fork Trinity River population units). Affects of SSC on distinct population units are differentiated where appropriate.

Coho salmon are distributed throughout the Klamath River downstream of Iron Gate Dam, and spawn primarily in tributaries (Trihey and Associates 1996, National Research Council [NRC] 2004). Rearing has also been observed in tributary confluence pools in the mainstem Klamath River (T. Shaw, USFWS, unpubl. data, 2002; as cited in NRC 2004). During their upstream migration, adult coho salmon from the Upper Klamath River Population Unit may travel upstream as far as Iron Gate Dam (RM 190.1) and were formerly known to occupy mainstem and tributary habitat at least as far upstream as Spencer Creek at RM 228 (NRC 2004, as cited in National Marine Fisheries Service [NOAAFisheries] 2007). Thus, the mainstem Klamath River functions primarily as a migration corridor for coho salmon, but also likely provides rearing habitat and allows for movement of juvenile fish between tributaries.

The vast majority of coho salmon that spawn in the Klamath Basin are believed to be of hatchery origin. Indirect estimates indicate 90 percent of adult coho salmon in the system return directly to hatcheries or spawning grounds in the immediate vicinity of hatcheries (Brown et al. 1994). This analysis of SSC effects pertains to the adults and progeny of both hatchery-returning adults and those that spawn in the river, differentiating between the two where possible.

Upstream migration of adult coho salmon in the Klamath River spans the period from September to January, with peak movement occurring between late-October and mid-November. As this is the only period when adults are present in the mainstem Klamath River, it is also the only period when they would be exposed to elevated suspended sediment in the mainstem. Under both normal and extreme conditions concentrations would be stressful (Tables E-6, E-7); however, the duration of time over which the exposure occurs is relatively short (<2 wk). Adults from the Trinity River population units and the Lower Klamath River Population Unit likely receive less exposure to suspended sediment due to shorter migration times than for populations further upstream.

Table E-6. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Coho Salmon under Normal Conditions (50% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1–Jan 1)	90 to 245	2	7	SSC only predicted to be in stressful range for 5 days. Adverse effects on adults assumed unlikely due to short period of exposure (5 days) that may only coincide with a portion of the run.
	33 to 90	3	7	
Spawning, incubation, and fry emergence (Nov 1–Mar 14)	245 to 665	2	10	No modeling of suspended sediment infiltration into gravel was conducted. Available information suggests low survival (<2%) of spawning adults, incubating eggs, and emergent fry in the mainstem; typically a small percentage of the percent of the Upper Klamath River Population spawns in the mainstem as opposed to tributaries.
	90 to 245	4	10	
	33 to 90	9	11	
Age-1 juveniles during winter (Nov 15–Feb 14)	245 to 665	2	8	Short-term (10 d) moderate stress for age 1 juveniles rearing the mainstem. An unknown but assumed small number of all juveniles (<1 %) rear in mainstem during winter.
	90 to 245	3	7	
	33 to 90	5	7	
Age-0 juveniles during summer (Mar 15–Nov 14)	90 to 245	6	8	Major stress for age 0 juveniles rearing in mainstem.
	33 to 90	19	8	
Age 1 juvenile outmigration (Feb 15–May 31)	245 to 665	1	7	Major stress for smolts outmigrating during early spring (~44 % of run).
	90 to 245	7	8	
	33 to 90	20	8	
Age 1 juvenile outmigration (Apr 1– June 30)	90 to 245	5	8	Major stress for smolts outmigrating during late spring (~56 % of run).
	33 to 90	16	8	

Table E-7. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Coho Salmon under Extreme Conditions (10% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1–Jan 1)	665 to 1,808	1	8	Moderate to major stress for adults migrating upstream.
	245 to 665	3	8	
	90 to 245	6	8	
	33 to 90	8	7	
Spawning, incubation, and fry emergence (Nov 1–Mar 14)	1,808 to 4,915	1	10	No modeling of suspended sediment infiltration into gravel was conducted. Available information suggests low survival (0%) of spawning adults, incubating eggs, and emergent fry in the mainstem; typically a small percentage of the percent of the Upper Klamath River Population spawns in the mainstem as opposed to tributaries
	665 to 1,808	2	10	
	245 to 665	5	11	
	90 to 245	14	12	
	33 to 90	14	11	
Age-1 juveniles during winter (Nov 15–Feb 14)	1,808 to 4,915	1	9	Major stress and reduced growth for age 1 juveniles rearing the mainstem. An unknown but assumed small number of all juveniles (<1 %) rear in mainstem during winter.
	665 to 1,808	2	8	
	245 to 665	5	8	
	90 to 245	10	8	
	33 to 90	11	8	
Age-0 juveniles during summer (Mar 15–14 Nov)	245 to 665	5	8	Major stress and reduced or no growth for age 0 juveniles rearing in mainstem.
	90 to 245	20	9	
	33 to 90	39	8	
Age 1 juvenile outmigration (Feb 15–May 31)	665 to 1,808	2	8	Major stress and reduced growth for smolts during early spring (~44 % of run).
	245 to 665	5	8	
	90 to 245	21	9	
	33 to 90	37	8	
Age 1 juvenile outmigration (Apr 1– June 30)	245 to 665	5	8	Major stress for smolts outmigrating during late spring (~56 % of run).
	90 to 245	16	8	
	33 to 90	20	8	

Spawning begins within a few weeks of fish arriving at their spawning grounds. Potential effects on the Upper Klamath River Population Unit spawning coho salmon in the mainstem were evaluated based on SSC predictions for the period November 1 to March 15 in the vicinity of Seiad Valley. The modeling analysis does not account for effects that might result from infiltration of fine sediment into the channel bed because no suitable measurements or models were available with which to calculate this component. However, cumulative effects of suspended sediment on spawning adults, incubating eggs, developing alevins, and emergent fry would result in low survival for any coho salmon spawning in the mainstem under both normal and extreme conditions, with possibly up to 100 percent mortality under extreme conditions in the vicinity of Seiad Valley

(Table E-7) and further downstream. However, coho salmon are typically tributary spawners (NOAAFisheries 2010), and based on Magneson and Gough (2006) spawning surveys from 2001 to 2005, only from 6 to 13 are observed in the mainstem, so elevated suspended sediment during winter flows can be assumed to have only minimal effects on the Upper Klamath River Population Unit. In addition, it is believed by experts in the watershed that progeny of mainstem spawning coho salmon experience reduced survival compared to fish produced from tributary spawners (Simondet 2006), since rearing and growth conditions within tributaries are more favorable than in the mainstem.

Varity of behavioral responses of coho salmon to exposure to SSC increases uncertainty in the analysis. There may be wide variation in terms of how long juvenile coho salmon rear in natal tributaries versus the mainstem, making it difficult to determine their exposure to elevated SSC in the mainstem. Some fry and age 0 juveniles enter the mainstem in the spring and summer following emergence. These fish may spend their remaining rearing period in the mainstem, but by the early fall, only low densities of juvenile coho salmon are found in the mainstem. The latter indicates that oversummer survival may be low due to high temperatures and exposure to disease in the mainstem Klamath River (NRC 2004). Even those that survive may experience reduced growth due to high summer temperatures, resulting in ocean entry at a smaller size and lower marine survival (Bilton et al. 1982, Hemmingsen et al. 1986). SSC modeling predicts that age 0 fish rearing in the mainstem during winter would also be exposed to suspended sediment concentrations high enough to cause major physiological stress even under normal conditions (Table E-6). Although some juveniles may rear in the mainstem, most production from all population units probably results from fish that remain to rear in tributaries.

Additional age 0 juveniles depart from tributaries in the Mid-Klamath and Salmon River population units (and possibly others) during fall (Soto et al. 2009, Hillemeier et al. 2009). Some of these have been observed to overwinter in tributaries and off-channel habitats in the lower mainstem Klamath River near or within the estuary (Soto et al. 2009, Hillemeier et al. 2009), which may reduce the amount of time they are exposed to suspended sediment in the mainstem.

Most juveniles from all population units appear to rear in tributaries or off-channel habitats during winter, and are not affected by mainstem pulses of suspended sediment until they migrate to the ocean as smolts, with the exception of potential migrations among tributaries (e.g., Ebersole et al. 2006). This seems to be the case for most naturally produced coho salmon, which depart tributaries from February through mid-June as age-1 smolts (Wallace 2004). During outmigrant trapping efforts from 1997 to 2006 in tributaries in the Upper-Klamath River, Shasta River, and Scott River populations, 44 percent of coho salmon smolts were captured from February 1 to March 31, and 56 percent from April 1 through the end of June (Courter et al. 2008). Once in the mainstem, smolts move downstream fairly quickly. Stutzer et al. (2006) report a median migration rate for wild coho smolts of 13.5 miles/day (range -0.09–114 miles/day) and a median migration rate for hatchery smolts of 14.6 miles/day (range -2.3–27.8 miles/day). This equates to 14.3 days for wild smolts to travel the 193 miles from Iron Gate Dam to the estuary, and 13.2 days for hatchery smolts. Beeman et al. (2007) report even higher rates of travel: a median migration rate for wild smolts of 22.5 miles/day (range 2.9–113.9 miles/day) and 15.7 miles/day (range 1.9–122.0 miles/day) for hatchery smolts. At these rates, it would take only 7.6 days (range 1.5-59.8 days) for wild smolts to travel from Iron Gate Dam to the estuary and 10.9 days (range 1.4–91.8 days) for hatchery smolts. Based on these data, and the observed outmigration rates for Chinook salmon of around 30 days, a maximum of 20 days exposure to mainstem suspended sediment during migration was assumed for the analysis. Under normal conditions, SSC in the mainstem Klamath River during outmigration for all populations would remain in the sublethal range but could result in major physiological stress and inhibit feeding. Suspended sediment concentrations under extreme conditions would be somewhat higher, and would result in major stress and reduced growth, but would remain in the sublethal range during the rearing and outmigration periods.

During experimental releases of wild and hatchery radio-tagged coho salmon smolts in the Klamath River near Iron Gate Dam sustained mortality rates of around 35 to 70 percent (Beeman et al. 2007, 2008). Although these numbers are based on only a few years of data, it appears that survival is higher for wild fish than for hatchery fish. This disparity in survival rates may be associated with (1) the length of residency in tributaries prior to migrating (i.e., fish that enter the mainstem later have higher survival), (2) mainstem discharge (migrants sometimes showed higher survival when flows in the mainstem were higher), or (3) spawning location (survival is much lower for smolts originating upstream of the Scott River). The relative contribution from SSC to these mortality rates is not known.

Overall, under existing conditions and the No Action/No Project Alternative, suspended sediment concentrations in the mainstem are sufficiently high and of long enough duration that major physiological stress and reduced growth of coho salmon are anticipated in most years. Consistent with these findings, the lower Klamath River downstream of the Trinity River confluence (RM 40.0) to the estuary mouth (RM 0.0) is listed as sediment impaired under Section 303(d) of the Clean Water Act (SWRCB 2006, NCRWQCB 2010) (Section 3.2.3.3). Relatively high SSC, in association with elevated water temperatures and disease may be contributing to the high smolt mortality that has been observed in the mainstem Klamath River (Beeman et al. 2007, 2008).

E.3.1.4 Summer- and Winter-run Steelhead

The following analysis and discussion applies to summer-, fall-, and winter-run steelhead (*Oncorhynchus mykiss*) (steelhead returning in the fall are sometimes lumped with the winter run) except where indicated. Because juvenile steelhead from various runs are indistinguishable from each other, the model assumes that steelhead from both the summer and winter runs share similar juvenile life-history patterns. The vast majority of existing information addresses steelhead rather than resident rainbow trout. This section primarily addresses steelhead, but it is reasonable to assume that effects of suspended sediment on resident *O. mykiss* will be similar to those found for juvenile steelhead.

Both summer and winter steelhead are distributed throughout the Klamath River and its tributaries downstream of Iron Gate Dam. Based on available escapement data, approximately 55 percent of summer steelhead spawn in the Trinity River and other lower-elevation tributaries. Most remaining summer steelhead are believed to spawn in tributaries between the Trinity River (RM 43) and Seiad Creek (RM 129), with high water temperatures limiting their use of tributaries farther upstream (NRC 2004). Winter steelhead spawn primarily in the Trinity, Scott, Shasta, and Salmon rivers.

Adult summer steelhead typically enter and migrate up the Klamath River from March through June (Hopelain 1998) and then hold in cooler tributary habitat until spawning begins in December (USFWS 1998). Summer steelhead in the Klamath River were reported by Hopelain (1998) to have a greater incidence of repeat spawning (40-64 percent) than the fall and winter runs, and a large proportion of adults are observed to migrate downstream to the ocean after spawning (also known as “runbacks”). Under normal conditions, SSC would remain in the sublethal range during adult migration; however, concentrations may be high enough to cause avoidance, physiological stress, and possibly impaired homing. Concentrations should still remain in the sublethal range under extreme conditions, but would be slightly higher and durations longer than under normal conditions.

In contrast to summer-run steelhead, winter-run are sexually mature upon freshwater entry (Papa et al. 2007). Upstream migration for adult fall-run steelhead in the Klamath River typically lasts from July to October and for adult winter-run steelhead from November through March (Hopelain 1998, USFWS 1998). Fall steelhead may be migrating as early as July, but elevated suspended sediment concentrations are uncommon during summer. Under normal conditions, SSC are high enough to cause major stress and possibly impaired homing for about three weeks. The 80 percent of steelhead spawning upstream of the Trinity River would be exposed for a longer period due to the additional time spent migrating in the mainstem. Under extreme conditions, SSC would cause major stress and impaired homing for around six weeks, twice the duration seen under normal conditions. Concentrations remain in the sublethal range; however, adults stressed by elevated suspended sediment could be more vulnerable to disease-related mortality. The amount of time that adults could be exposed will vary, depending on run timing relative to precipitation events that cause high SSC and how quickly an adult moves upstream and enters a spawning tributary.

Post-spawning adults, or “runbacks,” migrate downstream in the spring to return to the sea, typically from April through May 30. Under normal conditions, suspended sediment concentrations are high enough to cause major stress for a little over two weeks, but under extreme conditions the elevated concentrations occur for six weeks or more. If runbacks spend a limited amount of time in the mainstem while traveling from their spawning tributaries to the ocean, this may overestimate the duration of their exposure to sediment in the mainstem. There are little data on downstream-migrating steelhead in the Klamath with which to understand potential consequences of exposure to suspended sediment during this life history phase.

Half-pounders—sexually immature fish that return after one year in the ocean—migrate upstream in the late summer and remain in the Klamath River through March. On average, 32 percent of summer steelhead adults returning to the North Fork Trinity River are half-pounders (Hopelain 1998); the proportion of the summer run that employs this life-history pattern in the area upstream of the Trinity River is unknown. A large portion (~94 percent) of the fall steelhead run that spawns in tributaries upstream of Weitchpec return as half-pounders, as well as a large portion of adults returning to the Trinity River (~80 percent) (Hopelain 1998). The winter run has a much lower incidence of fish using the half-pounder life history, ~18 percent. Half-pounders tend to be found in the lower mainstem Klamath River, but they can be found all the way upstream to Beaver Creek from December through February. In a normal year under existing conditions and the No Action/No Project Alternative, suspended sediment concentrations in the mainstem during the period when half-pounders are present would be in a range that may cause major physiological stress, but would not be expected to be lethal or reduce growth (Table E-8). In an extreme year, suspended sediment concentrations would be somewhat higher, persist longer, and may reduce growth, but should also remain in the sublethal range (Table E-9).

No steelhead spawning occurs in the mainstem Klamath River; therefore, spawning adults, incubating eggs and developing alevins, and emergent fry should be unaffected by suspended sediment in the mainstem.

Juvenile summer steelhead in the Klamath Basin may rear in fresh water for up to three years before outmigrating. Although the majority of steelhead outmigrate at age 1 (Scheiff et al. 2001), those that outmigrate at age 2 appear to have the highest survival. (Hopelain 1998). Juveniles outmigrating from tributaries at age-0 and age-1 may rear in the mainstem for one or more years before reaching an appropriate size for smolting. Because juvenile steelhead may spend varying amounts of time between tributaries and the mainstem, it is difficult to track how much exposure each cohort might receive to suspended sediment in the mainstem. Juveniles found in the mainstem cannot generally be identified to run, so for the sake of the analysis the model assumes summer-, fall-, and winter-run fish share a similar life history with those that have been observed. In addition, there is some evidence in the literature that juvenile salmonids may actively avoid turbid waters by moving into tributaries, so behavior in years of relatively clear conditions may be different from that in years with elevated suspended sediment.

Table E-8. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Steelhead under Normal Conditions (50% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult summer upstream migrants and runbacks (Mar 1–June 30)	245 to 665	<1	7	Major stress, avoidance of turbidity, and possibly impaired homing.
	90 to 245	6	8	
	33 to 90	19	8	
Adult winter upstream migrants (Aug 1–Mar 31)	245 to 665	2	8	Major stress and potential for impaired homing.
	90 to 245	6	8	
	33 to 90	10	7	
Adult runbacks (Apr 1–May 30)	90 to 245	5	8	Moderate to major stress to downstream-migrating adults; effect dependent on time it takes runbacks to return downstream to the sea.
	33 to 90	14	7	
Half-pounder residence (Aug 15–Mar 31)	245 to 665	2	8	Major stress, and possibly reduce growth or cause mortality. Proportion of run that returns as half-pounders is unknown. Fish may escape exposure to high suspended sediment in the mainstem by entering tributaries.
	90 to 245	5	8	
	33 to 90	10	7	
Spawning though emergence	N/A	—	—	No mainstem spawning.
Age 0 juvenile rearing (Mar 15–Nov 14)	90 to 245	6	8	Major stress for portion of age 0 juveniles rearing in mainstem (~60% of run upstream of Trinity River)
	33 to 90	19	8	
Age 1 juvenile rearing (year-round)	245 to 665	2	8	Major stress for portion of age 1 juveniles rearing in mainstem (~60% of run upstream of Trinity River)
	90 to 245	9	8	
	33 to 90	22	8	
Age 2 juvenile rearing (Nov 15–Mar 31)	245 to 665	2	8	Age 2 in the mainstem (~40 percent of run upstream of Trinity River) expected to experience moderate to major stress. Effects on growth may only last 2-3 weeks, perhaps not enough to substantially reduce size and ocean survival.
	90 to 245	6	8	
	33 to 90	10	7	
Juvenile/smolt outmigrants (Apr 1–Nov 14)	90 to 245	5	8	Major stress.
	33 to 90	17	8	

Table E-9. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Steelhead under Extreme Conditions (10% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult summer migrants and runbacks (Mar 1–June 30)	665 to 1,808	1	9	Major stress, avoidance of turbidity, and impaired homing.
	245 to 665	5	8	
	90 to 245	21	8	
	33 to 90	37	8	
Adult winter migrants (Aug 1–Mar 31)	1,808 to 4,915	1	9	Major stress and impaired homing for about four months.
	665 to 1,808	2	9	
	245 to 665	5	9	
	90 to 245	15	8	
	33 to 90	20	8	
Adult runbacks (Apr 1–May 30)	245 to 665	4	8	Major stress; exposure duration dependant on time it takes runbacks to return to sea.
	90 to 245	11	8	
	33 to 90	28	8	
Half-pounder residence (Aug 15–Mar 31)	1,808 to 4,915	1	9	Major stress and reduced growth. Proportion of run returning as half-pounders is unknown. Some half-pounders use large tributaries. Fish may enter tributaries to escape high suspended sediment in the mainstem.
	665 to 1,808	2	9	
	245 to 665	10	9	
	90 to 245	15	8	
	33 to 90	24	8	
Spawning through emergence	—	—	—	No mainstem spawning.
Age 0 juvenile rearing (Mar 15–Nov 14)	245 to 665	5	8	Major stress and reduced growth for several months for age 0 rearing in mainstem (~60% of run upstream of Trinity River)
	90 to 245	20	9	
	33 to 90	39	8	
Age 1 juvenile rearing (year-round)	1,808 to 4,915	1	9	Major stress, reduced growth, and up to 20% mortality for age 1 rearing in mainstem (~60% of run upstream of Trinity River)
	665 to 1,808	2	8	
	245 to 665	7	9	
	90 to 245	25	9	
	33 to 90	39	9	
Age 2 juvenile rearing (Nov 15–Mar 31)	1,808 to 4,915	1	9	Major stress and reduced growth for >1 month for age 2 in mainstem (~40% of run upstream of Trinity River)
	665 to 1,808	2	8	
	245 to 665	5	8	
	90 to 245	15	8	
	33 to 90	20	8	
Juvenile/smolt outmigrants (Apr 1–Nov 14)	245 to 665	5	8	Major stress and reduced growth depending on duration of exposure.
	90 to 245	20	9	
	33 to 90	32	8	

Under normal existing conditions and the No Action/No Project Alternative, age 0 steelhead may experience major physiological stress for about three to four weeks (Table E-8). If they remain to rear in the mainstem for another year, suspended sediment concentrations would result in major stress for another month for this cohort. Under extreme existing conditions and the No Action/No Project Alternative, concentrations modeled for the age 0 period would cause major stress and reduced growth for about two months, and if they remain in the mainstem until smolting, the same cohort could be exposed to conditions causing reduced growth for an additional two months. However, it appears that many of these juveniles are avoiding conditions in the mainstem by using tributary and other off-channel habitat during winter (Soto et al. 2009, Hillemeier et al. 2009), lowering their exposure and potential mortality. The approximately 55 percent of the total summer steelhead population that spawn and rear in the Trinity River and downstream may be exposed to higher concentrations due to tributary accretion, but for shorter durations because of the shorter distance (and shorter travel time) from the sea to the mouths of their spawning tributaries.

Based on captures in tributaries and the mainstem, it appears that around 40 percent of the population rears in tributaries until age-2; upstream of the Trinity River confluence, around 37 percent of rearing steelhead in the mainstem (run unknown) are age 2, and 3 percent are age 3 (Scheiff et al. 2001). For these fish, suspended sediment in a normal year under existing conditions and the No Action/No Project Alternative may cause major stress for about two to three weeks. Under extreme conditions, the model predicts suspended sediment concentrations that may cause stress for about six weeks.

Smolts are captured in the mainstem and estuary throughout the fall and winter (Wallace 2004), but peak smolt outmigration normally occurs from April through June, based on estuary captures (Wallace 2004). Temperatures in the mainstem are generally suitable for juvenile steelhead, except for reaches upstream of Seiad Valley where summer water temperatures are considered stressful. Exposure of outmigrating juvenile and smolt steelhead to suspended sediment in the mainstem will depend on the timing of their outmigration relative to conditions contributing to elevated suspended sediment, as well as the length of time it takes them to outmigrate to sea. Approximately half of the population outmigrates from the Trinity River and tributaries downstream; the shorter distance to the sea should also shorten the time they are exposed to suspended sediment in the mainstem during outmigration. Under normal conditions, suspended sediment concentrations can cause major stress extend for about three weeks during the outmigration period (April 1 to November 14). Under extreme conditions, concentrations would be high enough to cause major stress and reduce growth for almost eight weeks, much longer than under normal conditions. Because of this, more smolts originating from tributaries farther inland (i.e., not produced from the Trinity River or lower-elevation streams) would likely be exposed to high suspended sediment concentrations (because there is a greater chance that their outmigration may coincide with a sediment pulse). The duration of their exposure will depend both on timing and rates of travel downstream (i.e., the amount of time spent in the mainstem). For smolts that are outmigrating in an active fashion, feeding may be less important, thus the effect of suspended sediment on growth may be relatively minimal in terms of overall survival.

E.3.1.5 Pacific Lamprey

At least four, and possibly five or six species of lamprey occur in the Klamath River system (Kostow 2002, FERC 2006, PacifiCorp 2006), of which only resident Klamath River lamprey and anadromous Pacific lamprey are present downstream of Iron Gate Dam (PacifiCorp 2004, FERC 2006). Pacific lamprey was chosen as the focal species, since most information on life-history, distribution, and habitat requirements is from this species. If basic patterns in distribution differ between the species (e.g., Klamath River lamprey are found in more abundance directly downstream of Iron Gate Dam), then effects could vary from those discussed here.

Pacific lamprey are present in the mainstem Klamath River and tributaries below Iron Gate Dam and in the Trinity, Salmon, Shasta, and Scott river basins (Hardy and Addley 2001, NRC 2004). Based on observations and available habitat, most ammocoete rearing likely occurs in the Salmon, Scott, and Trinity rivers, as well as in the mainstem Klamath River. The Klamath River upstream of the Shasta River appears to have less spawning and rearing habitat, and Pacific lamprey are not regularly observed there. Therefore, the review of existing conditions and the No Action/No Project Alternative focuses on exposure of Pacific lamprey life stages to suspended sediment in the mainstem Klamath River downstream of Seiad Valley.

There is not extensive literature on the effects of suspended sediment on lamprey. This analysis was based on the effects of SSC on salmonids, with the assumption that impacts on lamprey are likely less than or equal to those on salmonids. It is generally observed that most life stages of Pacific lamprey are more resilient to poor water quality than salmonids (Zaroban et al. 1999), so these assumptions are likely conservative.

Anadromous Pacific lamprey enter the Klamath Basin throughout the year, although numbers peak in early winter. Under existing conditions and the No Action/No Project Alternative, SSC during adult migration could cause major physiological stress under both normal (Table E-10) and extreme conditions (Table E-11), although the duration of exposure under extreme conditions might be about double that under normal conditions. Pacific lamprey are observed to spawn in the mainstem Klamath River, exposing ammocoetes to suspended sediment within the mainstem year-round. Under normal conditions, concentrations are anticipated to be high enough and last long enough (~5 weeks) to cause major physiological stress under normal conditions, and major stress and reduced growth for a longer period (~10 weeks) under extreme conditions (Table E-11).

Juvenile lamprey (ages 2 to 10) outmigrate to the ocean from the mainstem Klamath River and tributaries rear-round, with peaks in migration during late spring and fall. Based on effects on salmonids, juvenile lamprey migrating during spring are anticipated to be exposed to suspended sediment concentrations high enough to cause major stress under both normal and extreme conditions, with duration of exposure in extreme conditions (~6 weeks) being much longer than the duration under normal conditions (~two weeks). Juveniles migrating during fall are exposed to relatively low increases in suspended sediment for less than a week under normal conditions, and only about two weeks under extreme conditions (Table E-11). Based on data collected on salmonids, concentrations would cause physiological stress, but would remain in the sublethal range in most years.

Table E-10. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Pacific lamprey under Normal Conditions (50% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migration and spawning (year-round)	245 to 665	2	8	Major stress and potentially impaired homing for adult migrants. Adults migrating during late spring and summer are exposed to lower concentrations of SSC.
	90 to 245	9	8	
	33 to 90	22	8	
Ammocoete rearing (year-round)	245 to 665	2	8	Major stress of ammocoetes rearing in the mainstem. Majority of ammocoetes rear in tributaries.
	90 to 245	9	8	
	33 to 90	22	8	
Spring outmigration (May 1–June 30)	90 to 245	5	8	Major stress for all juveniles during spring outmigration.
	33 to 90	12	8	
Fall/winter outmigration (Sept 1–Dec 31)	90 to 245	2	7	Short-term (5 d) moderate stress and reduced feeding for all juveniles during fall outmigration.
	33 to 90	3	6	

Table E-11. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Pacific lamprey under Extreme Conditions (10% exceedance probability), for Klamath River at Seiad Valley (RM 129.4).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migration (year-round)	1,808 to 4,915	1	9	Major stress and impaired homing for adult migrants. Adult migrating during late spring and summer are exposed to lower concentrations of SSC.
	665 to 1,808	2	9	
	245 to 665	7	9	
	90 to 245	25	9	
	33 to 90	39	8	
Ammocoete rearing (year-round)	1,808 to 4,915	1	9	Major stress and reduced growth of ammocoetes rearing in the mainstem. Majority of ammocoetes rear in tributaries.
	665 to 1,808	2	8	
	245 to 665	7	9	
	90 to 245	25	9	
	33 to 90	39	8	
Spring outmigration (May 1–June 30)	245 to 665	5	8	Major stress for all juveniles during spring outmigration.
	90 to 245	14	8	
	33 to 90	21	8	
Fall/winter outmigration (Sept 1–Dec 31)	665 to 1,808	1	8	Major stress for all juveniles during spring outmigration.
	245 to 665	3	8	
	90 to 245	5	8	
	33 to 90	7	7	

To summarize, under both normal and extreme conditions, Pacific lamprey are anticipated to suffer from stressful levels of suspended sediment while rearing and migrating through the mainstem Klamath River, with exposure durations generally much longer under extreme conditions. Because there are multiple year-classes of lamprey in the mainstem Klamath River at any given time, and since adults may migrate upstream throughout the year, Pacific lamprey populations may be well-adapted to persisting through years when suspended sediment concentrations are high, especially since they remain within the sublethal range based on salmonid data.

E.3.1.6 Green Sturgeon

The Klamath Basin is the principal spawning watershed for green sturgeon in California (Moyle 2002). Green sturgeon spawn primarily in the lower 67 miles of the mainstem Klamath River (downstream of Ishi Pishi Falls), in the Trinity Rivers upstream to Greys Falls, and potentially in the lower Salmon River upstream to Wooley Creek (KRBFTF 1991, Adams et al. 2002, Benson et al. 2007). Based on this distribution, this analysis focuses on exposure of green sturgeon life stages to suspended sediment in the mainstem downstream of Orleans.

There is not extensive literature on the effects of suspended sediment on sturgeon. This analysis is based on available information of the effects of SSC on salmonids, with the assumption that effects of suspended sediment on sturgeon are likely less than or equal to those on salmonids. It is generally believed that most life stages of sturgeon are more resilient to turbidity than salmonids, so these assumptions are likely conservative. For example, juvenile green sturgeon exposed to high suspended sediment in the Connecticut River showed no apparent physiological stress, even though several other sturgeon species suffered gill infections (B. Kynard, Fisheries Biologist, BK-Riverfish, pers. comm., 2008). During extensive radio telemetry studies of green sturgeon, McCovey (2010) found that adults did not respond to periods of poor water quality, including high water temperature, algal blooms, disease outbreaks, and pulses of suspended sediment. In addition, adults have been observed to remain alive for days out of water, and no adult or juvenile sturgeon mortalities were observed during the September 2002 fish kill in the lower Klamath River.

Adult green sturgeon enter the Klamath River beginning in mid-March, and under both normal and extreme conditions suspended sediment concentrations reach levels expected to cause physiological stress in salmonids. Adult sturgeon are likely to be relatively tolerant compared to salmonids, however. Feeding is not likely to be a problem even when suspended sediment concentrations are high, because they do not generally rely on eyesight to feed, but instead feed primarily on invertebrates in mud and silt using sensitive barbels to detect prey, and they may suspend feeding for long periods during their spawning migration (EPIC et al. 2001, as cited in California Department of Water Resources [CDWR] 2003).

Green sturgeon females are broadcast spawners that lay thousands of adhesive eggs that settle into the spaces between cobble substrates (Moyle 2002; Emmett et al. 1991, as cited in CALFED 2007). It is generally believed that silt can cause mortality by preventing eggs from adhering to one another and attaching to the substrate (EPIC et al. 2001, as cited in CDWR 2003). Under normal conditions, eggs and larvae are expected to be exposed to suspended sediment concentrations over 50 mg/l for a period of about three weeks, which based on the Newcombe and Jensen (1996) approach would be expected to cause high rates of mortality of salmonid eggs and emergent fry, yet green sturgeon do successfully spawn in the mainstem Klamath River under existing conditions and the No Action/No Project Alternative (Benson et al. 2007), and while some mortality is likely occurring, it is likely that effects are not as severe as suggested for salmonids.

After spawning, around 25 percent of green sturgeon migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools in the Klamath River from RM 13 to RM 65 through November. During this holding period, SSC are relatively low, and no effects are anticipated under normal conditions; under extreme conditions, SSC would be elevated to levels moderately stressful to salmonids, but only for a few days.

Juvenile green sturgeon may rear for one to three years in the Klamath River system before they migrate to the estuary and ocean (NRC 2004, FERC 2006, CALFED 2007), usually during summer and fall (Emmett et al. 1991, as cited in CALFED 2007). Juveniles are reported to grow rapidly, and are capable of entering the ocean at young ages (Allen and Cech 2007, as cited in Klimley et al. 2007). Rearing for more than one year is rarely observed in the mid-Klamath River (M. Belchik, Fisheries Biologist, Yurok Tribe, pers. comm., 2008), but juveniles may be rearing for additional months or years in the lower river or estuary before migrating to the ocean. During the rearing period, juveniles are anticipated to be exposed to SSC that cause major stress and reduced growth in salmonids for about a month under normal conditions and double that under extreme conditions (Tables E-12, E-13). However, juvenile green sturgeon exposed to high suspended sediment in the Connecticut River showed no apparent physiological stress, even though several other sturgeon species suffered gill infections (B. Kynard, Fisheries Biologist, BK-Riverfish, pers. comm., 2008). Green sturgeon eggs sampled in the Klamath River by Van Eenennaam et al. (2006) were the largest recorded for a North American sturgeon, and likely produce large, fast-growing juveniles. These traits may allow them to migrate to the estuary or ocean after only one year of residence (Van Eenennaam et al. 2006). This is consistent with observations of high growth rates in the mid-Klamath River (M. Belchik, Fisheries Biologist, Yurok Tribe, pers. comm., 2008), and may be related to the fact that the lower Klamath River and estuary offer very little foraging habitat compared with large systems such as the Sacramento-San Joaquin Bay-Delta, or Columbia River estuaries (J. Van Eenennaam, Research Associate, University of California Department of Animal Science, pers. comm., 2008).

Overall, under existing conditions and the No Action/No Project Alternative, green sturgeon in the Klamath River mainstem are regularly exposed to suspended sediment concentrations documented to cause major physiological stress, reduced growth, and mortality in salmonids, especially during their egg and larval stages, and the year-round juvenile rearing period. However, these metrics likely overestimate effects on sturgeon.

Table E-12. Predicted Suspended Sediment Concentration, Exposure Duration, and Anticipated Effects on Green Sturgeon under Normal Conditions (50% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (Timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult migration and spawning (Mar 15–July 15)	90 to 245	3	7	Moderate to major stress for adult migrants and spawners.
	33 to 90	24	8	
Eggs and larvae (Apr 1–Aug 15)	90 to 245	2	10	Up to 68% mortality for eggs and larvae (based on salmonid literature, effects likely overestimated).
	33 to 90	22	12	
Adult post-spawning holding (July 15–Nov 15)	0	—	—	No effects anticipated.
Juvenile rearing (year-round) and outmigration (May 15–Oct 15)	245 to 665	1	7	Major stress (based on salmonid literature, effects likely overestimated).
	90 to 245	5	8	
	33 to 90	24	8	

Table E-13. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Green Sturgeon under Extreme Conditions (10% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Mar 15–July 15)	245 to 665	2	8	Major stress for adult migrants and spawners.
	90 to 245	14	8	
	33 to 90	34	8	
Eggs and larvae (Apr 1–Aug 15)	245 to 665	<1	8	Up to 84% mortality for eggs and larvae (based on salmonid literature, effects likely overestimated).
	90 to 245	14	12	
	33 to 90	31	12	
Adult post-spawning holding (July 15–Nov 15)	90 to 245	1	7	Short duration and relatively low concentrations not expected to result in adverse effects on adults. About 75% of adults remain holding in the mainstem after spawning; remainder migrates to ocean.
	33 to 90	2	7	
Juvenile rearing (year-round) and outmigration (May 15–Oct 15)	665 to 1,808	2	8	Major stress and reduced or no growth (based on salmonid literature, effects likely overestimated).
	245 to 665	6	9	
	90 to 245	18	9	
	33 to 90	37	8	

E.3.2 Proposed Action– Full Facilities Removal of Four Dams

Under the Proposed Action, full facility removal would result in the release of 1.2-2.9 million metric tons of fine sediment stored in the reservoirs into the Klamath River downstream of Iron Gate Dam over a two-year period (Reclamation 2011), resulting in higher suspended sediment concentrations than would normally occur under existing conditions and the No Action/No Project Alternative (Figure E-3), and local, short-term sediment deposition. SSC would begin to increase during reservoir drawdown, prior to the deconstruction of the dams and continue to rise through the spring runoff period as material behind the dams is mobilized downstream. Reservoir drawdown is expected to commence in January 2020. Based on the suspended sediment modeling conducted to analyze each alternative (including facility removal) (Reclamation 2011), suspended sediment concentrations are expected to exceed 1,000 mg/l for weeks, with the potential for peak concentrations exceeding 5,000 mg/l for hours or days, depending on hydrologic conditions during facility removal. The transport of this suspended sediment load is expected to affect anadromous fish species in various ways; in the following sections, the predicted effects of SSC on each focal fish species and cohort (referenced by the year of birth) are analyzed to evaluate the likely effects of the Proposed Action on anadromous fish populations in the Klamath River.

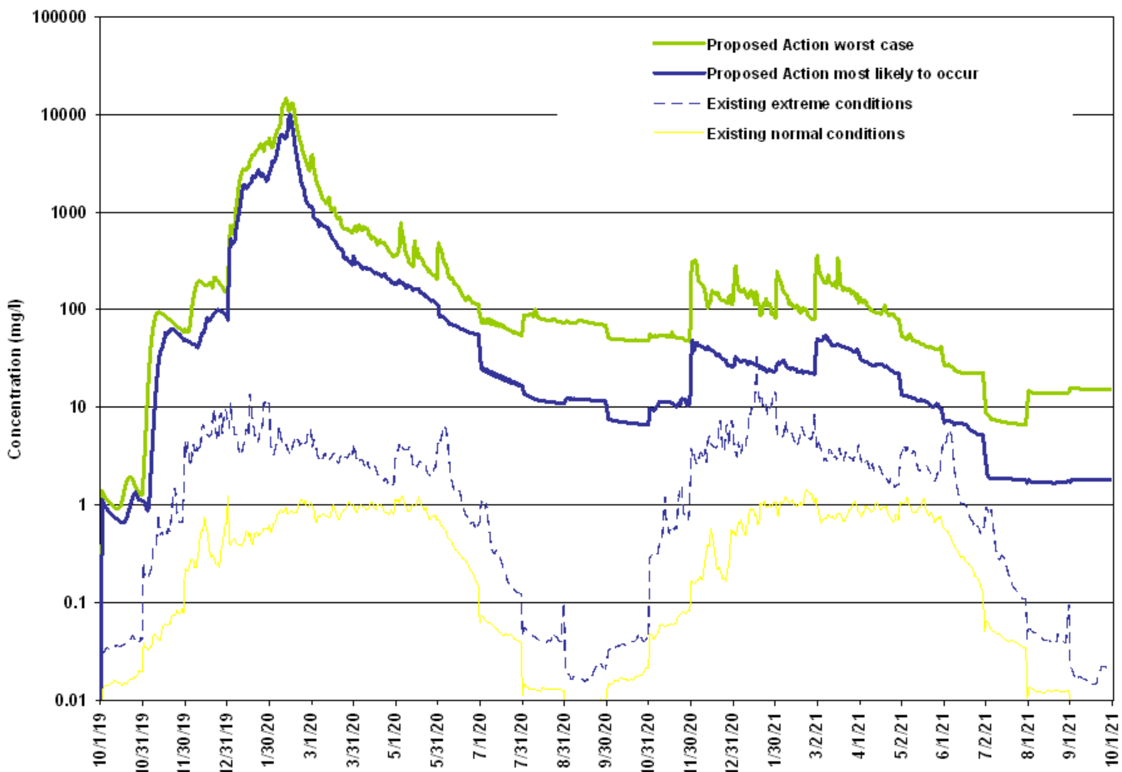

Figure E-3. Comparison of SSC under Proposed Action and Existing Conditions and the No Action/No Project Alternative at Iron Gate Dam for the Two-Year Period following Reservoir Drawdown beginning January 1st 2020, as Predicted using SRH-1D Model.

In the sections below, SSC predicted for the most likely and worst-case scenarios are used to evaluate the potential effects of the Proposed Action on anadromous fish species.

E.3.2.1 Fall-run Chinook Salmon

Although fall-run Chinook salmon migrate as far upstream as Iron Gate Dam to spawn, they are primarily distributed downstream of Seiad Valley. Therefore the assessment of effects focuses on exposure of fall-run Chinook salmon adult migrants and spawning to suspended sediment in the mainstem downstream of downstream of Iron Gate Dam, and downstream of Seiad Valley for all other life stages.

Adult fall-run Chinook salmon in the Klamath River migrate upstream from August through October, when suspended sediment levels are generally low, and typically take two to four weeks to reach their spawning grounds. Under the Proposed Action, SSC in the mainstem Klamath River during this migratory period is predicted to be nearly the same as under existing conditions and the No Action/No Project Alternative, with the exception that suspended sediment concentrations would be high enough to cause major physiological stress and impaired homing in the fall immediately following removal of the dams (2020).

Fall-run Chinook salmon spawning typically peaks in late October and substantially declines by the end of November (Shaw et al. 1997). The SSC modeling analysis does not account for potential effects that might result from infiltration of fine sediment into the channel bed because no suitable measurements or models were available with which to calculate this component; however, suspended sediment resulting from the Proposed Action is predicted to result in 100 percent mortality of eggs and fry from all mainstem Klamath River spawning in 2019 (Table E-14). The sediments released during dam removal will likely be primarily conveyed as wash load and will not fall out of suspension; however, the fraction deposited on spawning gravels will carry high concentrations of very fine sediment. These sediments may smother the eggs by adhering to the chorion [1] (Greig et al. 2005, Levasseur et al. 2006). The degree to which sediments will adhere to the egg is affected by the properties (e.g., angularity) of the minerals within the sediment. Sediment transport analysis conducted by Stillwater Sciences (2008) concluded that fine sediment infiltration is expected to be limited to the upper portion of the bed surface, which can be readily flushed during a high-flow event after the fine sediment supply in the former reservoir area is exhausted, or would be removed by the redd construction activities of spawning fish in subsequent years. Therefore, since the majority of sediment is predicted to be released within the first year following reservoir drawdown, the effect of fine sediment from the Proposed Action on spawning success is unlikely to persist beyond the summer of 2020.

Much of the overall effect of the Proposed Action on fall-run Chinook salmon will depend on the relative proportion of mainstem spawners during the fall of 2019, prior to the January 2020 initiation of facility removal. Based on redd surveys using a mark and re-sight methodology from 2001 through 2009 (California Department of Fish and Game, unpubl. data), an average of around 9,300 hatchery and naturally returning adults spawn in mainstem Klamath River, which is consistently around ~8 percent (range from 5.3 to 13.5 percent) of the total escapement in the Klamath Basin (not including grilses). Spawner surveys conducted by USFWS indicate that approximately half of the fall Chinook that spawn within the 82-mile survey reach construct their redds in the 13.5-mile section between Iron Gate dam and the Shasta River (FERC 2006) and thus would be most vulnerable to sediment released in association with the Proposed Action. Based on the long-term average of 8 percent, 9,300 adults could spawn in the mainstem downstream of Iron Gate Dam in the fall of 2019. Assuming two fish per redd, and with a predicted 100 percent mortality, around 4,600 redds could be lost under the Proposed Action assuming either the mostly-likely or worst-case scenario. Assuming constructed redds are related to escapement, this equates to around 8 percent of all anticipated redds in the basin in 2019. Based on the proximity to the Iron Gate Hatchery, it is expected that much of the redds affected will be of hatchery origin.

Approximately 60 percent of the fry produced by fall-run Chinook salmon in the Klamath River exhibit the Type I life history, in which they enter the ocean within a few months of emergence in early spring. Type I fry enter the mainstem in April and May. As discussed in Section E.3.1.1, a maximum duration of exposure to SSC during migration of 30 days was assumed for the analysis. Under the Proposed Action, SSC in the mainstem will likely result in major physiological stress and reduced growth under either the mostly-likely or worst-case scenario, which is also predicted under both normal and extreme existing conditions and the No Action/No Project Alternative (Tables E-14 and E-15). Prolonged exposure could affect early marine survival by reducing growth and thus the size at which the smolts enter the ocean (Bilton 1984). This would also be expected to be the case under existing conditions and the No Action/No Project Alternative even in normal years, but to a lesser degree. Exposure to disease or elevated temperatures during this phase would likely result in the mortality of some portion of these fish. Parr-smolt transformation can also be compromised in stressed juveniles (Wedemeyer and McLeay 1981, as cited in Bash et al. 2001), and act as a potential source of mortality.

The Type II life history is also common (~40 percent of cohort) (Sullivan 1989). These juveniles remain to rear in the tributaries in which they were spawned and will only be exposed to suspended sediment in the mainstem during their outmigration to the ocean in the fall. Under the Proposed Action, SSC would be very low, similar to existing conditions and the No Action/No Project Alternative, unless there are worst-case conditions in the fall after dam removal (2020), in which case SSC would be high enough to cause moderate to major physiological stress for a period of one to two weeks.

Type III life-history fish are relatively rare (<1 percent of production) in the Klamath River fall-run population (USFWS 2001). These fish typically remain to rear in the spawning tributaries and outmigrate in late winter and early spring as yearlings. Under the Proposed Action, SSC could cause up to 20 percent mortality, and up to 100 percent mortality in a worst-case scenario (Tables E-14 and E-15). Under existing conditions and the No Action/No Project Alternative, suspended sediment concentrations remain in the sublethal range (Table E-15). Based on outmigrant trapping in the mainstem Klamath

River at Big Bar, around 942,829 Chinook salmon smolts outmigrate each spring, including both hatchery and naturally produced fish (USFWS 2001). Type III age 1 spring outmigrants are very rare, and only 31 were observed at Big Bar in four years of trapping, or around 0.1 percent of trap captures. Based on abundance estimates annual average Type III outmigration is around 943 smolts each year. Based on model predictions of 0 to 20 percent mortality, around 0 to 189 smolts could perish, or around 0.02 percent of the total fall-run Chinook salmon smolt production. This does not take into account Type II outmigrants during fall which are not sampled in the Klamath River, so the actual percentage could be lower. Under a worst case scenario mortality rates of up 71 percent are predicted for the Proposed Action, equating to up to 669 smolts, or around 0.07 percent of the total fall-run Chinook salmon smolt production. Based on Sullivan (1989) the typically larger Type III smolts can contribute up to 4 percent of the escapement despite their low proportion of smolt production, perhaps due to their larger size at ocean entry (Bilton 1984). Therefore the effect on the population of mortality to the Type III smolts may be proportionally higher than the effect of mortality of other life-histories.

Table E-14. Suspended Sediment Predictions for Fall-Run Chinook Salmon for most likely Scenario (50% exceedance probability), Klamath River at Iron Gate Dam (adult migration, spawning, incubation, and fry emergence life stages) and Seiad Valley (juvenile rearing and outmigration life stages).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (July 15–Oct 31 2020)	0	0	0	No effect anticipated.
Spawning, incubation, and fry emergence (Oct 15 2019–Feb 28 2020)	4,915 to 13,360	10	12	Effects of suspended sediment on spawning gravel quality were not modeled; however, suspended sediment may result in nearly 100% mortality of all progeny from mainstem spawning (approximately 4,600 redds, or around 8% of production).
	1,808 to 4,915	14	13	
	665 to 1,808	8	12	
	245 to 665	5	11	
	90 to 245	10	11	
	33 to 90	27	10	
Juvenile rearing (Fall 2019 through 2020)	n/a	n/a	n/a	No juvenile progeny anticipated from mainstem due to impacts during incubation. All other juveniles rear in tributaries.
Type I outmigration (April 1–August 31 2020)	245 to 665	4	8	Major stress and reduced growth. Applies to ~60% of total production.
	90 to 245	19	9	
	33 to 90	21	8	
Type II outmigration (Sept 1–Nov 30 2020)	0	0	0	No effect anticipated.
Type III outmigration (Feb 1–April 15 2020)	1,808 to 4,915	11	10	Major stress, reduced growth and up to 20% mortality. (0 to 189 smolts, or less than 1% of production).
	665 to 1,808	8	9	
	245 to 665	11	9	
	90 to 245	11	8	

Table E-15. Suspended Sediment Predictions for Fall-Run Chinook Salmon for Worst-Case Scenario (10% exceedance probability), Klamath River at Iron Gate Dam (adult migration, spawning, incubation, and fry emergence life stages) and Seiad Valley (juvenile rearing and outmigration life stages).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult migration (July 15–Oct 31 2020)	90 to 245	5	8	Major stress and impaired homing for migrating adults.
	33 to 90	58	8	
Spawning, incubation, and fry emergence (Oct 15 2019–Feb 28 2020)	13,360 to 36,316	1	11	Effects of suspended sediment on spawning gravel quality were not modeled; however, suspended sediment may result in nearly 100% mortality of all progeny from mainstem spawning (approximately 4,600 redds, or around 8% of production).
	4,915 to 13,360	18	13	
	1,808 to 4,915	28	13	
	665 to 1,808	17	12	
	245 to 665	8	11	
	90 to 245	20	12	
	33 to 90	43	13	
Juvenile rearing (year round)	n/a	n/a	n/a	No juvenile progeny anticipated from mainstem due to impacts during incubation. All other juveniles rear in tributaries.
Type I outmigration (Apr 1–Aug 31 2020)	665 to 1,808	1	8	Major stress and reduced growth. Applies to ~60% of total run progeny.
	245 to 665	12	9	
	90 to 245	30	9	
	33 to 90	30	8	
Type II outmigration (Sept 1–Nov 30 2020)	245 to 665	<1	6	Moderate to major stress. Applies to ~40% of total run progeny.
	90 to 245	4	8	
	33 to 90	6	7	
Type III outmigration (Feb 1–Apr 15 2020)	4,915 to 13,360	5	11	Major stress, reduced growth, and up to 71% mortality. (Up to 669 smolts, or less than 1% of production).
	1,808 to 4,915	17	11	
	665 to 1,808	13	10	
	245 to 665	18	9	
	90 to 245	25	9	
	33 to 90	8	7	

E.3.2.2 Spring-run Chinook Salmon

Based on spring-run Chinook salmon distribution, the Proposed Action will have the largest effect on spring-run Chinook salmon returning to or emigrating from the Salmon River. Therefore, this assessment focuses on life stages most likely to be found in the mainstem downstream of the Salmon River, including those that migrate to and from the Trinity River.

Under existing conditions and the No Action/No Project Alternative, and the Proposed Action, SSC during upstream migration would cause moderate-to-major stress and impaired homing, with duration of exposure expected to be slightly longer (2–7 days) under the Proposed Action than under existing conditions and the No Action/No Project Alternative. Adults migrating later in the season (July through August) are exposed to elevated suspended sediment for less than two days under any scenario, existing or proposed.

Spring-run Chinook upstream migration is separated into two time periods—spring and summer. Under the Proposed Action (most-likely and worst-case scenarios), spring migrants are expected to be exposed to higher concentrations of SSC than under existing conditions and the No Action/No Project Alternative, leading to increased stress and impaired homing (Table E-16). However, the duration of exposure is relatively short (<14 days), and effects are expected to be sublethal. Behavioral responses of adult salmon to high suspended sediment can include straying into nearby tributaries with lower levels of suspended sediment and ceasing or delaying upstream movements when there are no clearer waters to take refuge in (Cordone and Kelley 1961). Whitman et al. (1982) found that adult male Chinook showed an avoidance response to their home water when exposed to an ash suspension of 650 mg/l, but no indication that homing was affected. The increased energy expenditure that may result from a delay in migration can potentially reduce spawning success (Berman and Quinn 1991), particularly if factors such as elevated temperatures or disease are a problem.

Around half of the observed spring Chinook salmon adults migrate relatively rapidly to the Trinity River in the summer (~ 2 days within mainstem Klamath River). Under a worst-case scenario, effects would be nearly identical to existing conditions and the No Action/No Project Alternative —only one to two days of exposure to concentrations causing moderate stress (Table E-17).

Since no spring-run Chinook salmon spawning occurs in the mainstem Klamath River under existing conditions and the No Action/No Project Alternative, the egg through fry life stages are not anticipated to be affected by suspended sediment resulting from the Proposed Action (Tables E-16 and E-17).

Based on outmigrant trapping in the Salmon River from 2001 to 2006 (Karuk Tribe, unpubl. data), around 80 percent of outmigrants are Type I, 20 percent are Type II, and less than 1 percent are Type III. Based on otolith analysis conducted by Olson (1996), most adults returning to the Salmon River (~70 percent) exhibited the Type II life history and outmigrated during fall, and around 7 percent exhibited the Type III life history despite being infrequently observed outmigrating. Juvenile spring-run Chinook of both Types I and II are believed to rear in tributaries for the most part (West 1991; Dean 1994, 1995), reducing likelihood of exposure to suspended sediment in the mainstem. Type I juveniles move from tributaries into the mainstem and continue downstream to the ocean in April and May. Suspended sediment concentrations would cause moderate-to-major stress during the Type I outmigration under all scenarios, both existing and proposed, with duration of exposure 20 days under normal existing conditions and the No

Action/No Project Alternative and 28 days under the most-likely scenario of the Proposed Action. Since a maximum exposure of 30 days was assumed for outmigration, the worst-case scenario of the Proposed Action would be almost equivalent to extreme existing conditions and the No Action/No Project Alternative —30 days with major physiological stress.

Table E-16. Predicted Suspended Sediment Concentration, Exposure Duration, and Anticipated Effects on Spring-run Chinook Salmon for most likely Scenario (50% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult spring migration (Apr 1–Jun 30, 2020)[a]	90 to 245	9	8	Major stress and impaired homing for adults returning to Salmon River. Majority (~95% on average) of adults enter Trinity River, and will be exposed to lower concentrations. However, up to 35% of "natural" escapement returns to Salmon River.
	33 to 90	14	7	
Adult summer migration (Jul 1–Aug 31, 2020)[b]	0	0	0	No effect to the ~50% of the summer migrants returning to Trinity River.
Spawning, incubation, and fry emergence (Sept 1 2019–Feb 28, 2020)	n/a	n/a	n/a	Spring-run do not generally spawn in the mainstem.
Juvenile rearing (variable)	n/a	n/a	n/a	Juveniles rear in tributaries; no effect to this life stage is anticipated.
Type I outmigration (Apr 1–May 31, 2020) [c]	90 to 245	7	8	Major stress for Type I fry (~80%) in smolt outmigration from Salmon River. Majority (~95%) of juveniles outmigrate from the Trinity River, and will be exposed to lower concentrations.
	33 to 90	21	8	
Type II outmigration (Oct 1–Nov 15, 2020)[c]	0	0	0	No SSC exposure, no effect for Type II smolts from the Salmon River (~20%) during downstream migration. Majority (~95%) of juveniles outmigrate from Trinity River and are also exposed to no SSC from Proposed Action.
Type III outmigration Jan 15–May 31, 2020)[c]	1,808 to 4,915	2	9	Stressful conditions resulting in reduced growth and up to 20% mortality for Type III smolts from Salmon River. (around 16 smolts, less than 1% of the total smolt population from the Salmon River).
	665 to 1,808	17	10	
	245 to 665	8	9	
	90 to 245	16	8	
	33 to 90	23	8	

a Maximum duration of exposure during migration =14 days.
b Maximum duration of exposure during migration = 2 days.
c Maximum duration of exposure during migration = 30 days

Table E-17. Predicted Suspended Sediment Concentration, Exposure Duration, and Anticipated Effects on Spring-Run Chinook Salmon for Worst-Case Scenario (10% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult spring migration (Apr 1–Jun 30, 2020)[a]	245 to 665	6	9	Major stress and impaired homing for adults returning to Salmon River. Majority (~95% on average) of adults enter Trinity River, and will be exposed to lower concentrations. However, up to 35% of "natural" escapement returns to Salmon River.
	90 to 245	14	8	
	33 to 90	14	7	
Adult summer migration (Jul 1–Aug 31, 2020)[b]	33 to 90	2	7	Impaired homing for the approximately 50% of the summer migration returning exclusively to the Trinity River.
Spawning, incubation, and fry emergence (Sept 1 2019–Feb 28, 2020)	n/a	n/a	n/a	Spring-run do not generally spawn in the mainstem.
Juvenile rearing (variable)	n/a	n/a	n/a	Juveniles rear in tributaries; no effect to this life stage is anticipated.
Type I outmigration (Apr 1–May 31, 2020)[c]	245 to 665	3	8	Major stress for Type I fry (~80%) in smolt outmigration from Salmon River. Majority (~95%) of juveniles outmigrate from the Trinity River, and will be exposed to lower concentrations.
	90 to 245	16	8	
	33 to 90	34	8	
Type II outmigration (Oct 1–Nov 15, 2020)[c]	90 to 245	1	7	Moderate stress for Type II smolts from the Salmon River (~20%) during downstream migration. Same effects as under existing conditions.
	33 to 90	2	6	
Type III outmigration Jan 15–May 31, 2020)[c]	1,808 to 4,915	6	10	Stressful conditions resulting in reduced or no growth and up to 36% mortality for Type III smolts from Salmon River. (up to 28 smolts, less than 1% of the total smolt population from the Salmon River).
	665 to 1,808	30	10	
	245 to 665	16	9	
	90 to 245	25	9	
	33 to 90	30	8	

a Maximum duration of exposure during migration =14 days.
b Maximum duration of exposure during migration = 2 days.
c Maximum duration of exposure during migration = 30 days

Under existing conditions and the No Action/No Project Alternative, and the Proposed Action, SSC during the Type II outmigration would cause moderate-to-major stress for one to three days, and only under extreme existing conditions and the No Action/No Project Alternative or the worst-case scenario of the Proposed Action.

Type III outmigrants that overwinter in the mainstem Klamath River when SSC are highest, or those migrating from the Salmon River (<1 percent of outmigrants within Klamath River watershed), will have the greatest exposure to suspended sediment. Suspended sediment conditions would cause major physiological stress during the Type III outmigration under both normal and extreme existing conditions and the No Action/No Project Alternative, but remain in the sublethal range. Type III age 1 spring outmigrants are very rare (only 30 were observed in the Salmon River in five years of trapping). Based on model predictions of 0 to 20 percent mortality under a most likely to occur scenario, around 16 smolts would perish at worst, or less than 1 percent of the total smolt population from the Salmon River, and an even smaller percentage of the total production from the Klamath Basin. Under a worst case scenario mortality rates of 20 to 36 percent are predicted, or around 28 smolts at worst (<1 percent of production). However, based on Olson (1996) the typically larger Type III smolts can contribute up to 7 percent of the escapement despite their low proportion of smolt production, perhaps due to their larger size at ocean entry (Bilton 1984). Therefore the effect on the population of mortality to the Type III smolts may be proportionally higher than the effect of mortality of other life-histories. Most spring-run outmigrants (95 percent) originate from the Trinity River; they have a shorter distance to travel to the ocean and suspended sediment concentrations resulting from the Proposed Action should be lower due to dilution (Reclamation 2011), so they may experience major stress, but suffer little or no mortality.

E.3.2.3 Coho Salmon

As described in Section E.3.1.3, the affects of suspended sediment on coho salmon in the Klamath River described here follow the Williams et al. (2006) designation of nine population units. Although coho salmon within the Upper Klamath River Population Unit do migrate as far upstream as Iron Gate Dam, in general coho salmon are primarily distributed within tributaries downstream of the Shasta River. Therefore, the analysis focuses on exposure to suspended sediment within, and downstream of, Seiad Valley. Fish within the Upper Klamath River Population Unit upstream of Seiad Valley could be expected to be exposed to slightly higher SSC concentrations, and fish rearing in all other population units further downstream to lower concentrations.

Adult coho salmon enter the Klamath River between late September and mid-December, with peak upstream migration occurring between late October and mid-November. Based on adult migration observations in Scott River (2007–2009), Shasta River (2007-2009), and Bogus Creek (2003–2009), on average only around 4 percent of adult remain in the mainstem after December 15th (initiation of reservoir drawdown under the Proposed Action) (California Department of Fish and Game, unpubl. data). In most years all adults are observed prior to December 15th, although in some years (e.g., Scott River in 2009) most fish are observed between December 15th and January 1st. Therefore, most adult coho should already be in tributaries when reservoir drawdown begins in January 2020 (Table E-18 and E-19), especially those returning the shorter migration distances to the Trinity River and Lower Klamath River populations. Under the most likely and worst case scenarios, effects of the Proposed Action on migrating adults from all population units are anticipated to be slightly higher than those experienced under existing conditions and the No Action/No Project Alternative, but will remain sublethal (Table E-18 and E-19). The worst-case scenario under the Proposed Action would differ from extreme existing conditions only in extending the duration of exposure to elevated suspended sediment by a week.

Table E-18. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Coho Salmon for Proposed Action most likely Scenario (50% exceedance probability), Klamath River at Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1, 2019–Jan 1, 2020)	245 to 665	<1	7	Major stress and impaired homing for adults migrating upstream (~4% of all populations exposed).
	90 to 245	5	8	
	33 to 90	20	8	
Spawning, incubation, and fry emergence (Nov 1, 2019–Mar 14, 2020)	1,808 to 4,915	14	13	Effects of suspended sediment on spawning gravel quality were not modeled; however, suspended sediment may result in nearly 100% mortality of progeny from mainstem spawning. (~13 redds, or 0.7–26% of Upper Klamath River Population unit natural escapement).
	665 to 1,808	11	12	
	245 to 665	10	12	
	90 to 245	6	11	
	33 to 90	20	12	
Age-1 juveniles during winter (Nov 15, 2019–Feb 14, 2020)	1,808 to 4,915	4	10	Reduced growth and up to 20% mortality for age 1 juveniles from the 2019 cohort rearing in the mainstem. An unknown but assumed small number (<1%) of juveniles rear in mainstem during winter.
	665 to 1,808	8	9	
	245 to 665	7	9	
	90 to 245	5	8	
	33 to 90	17	8	
Age-0 juveniles during summer (Mar 15– Nov 14, 2020)	245 to 665	7	9	Reduced growth for age 0 juveniles from 2019 cohort rearing in mainstem during late spring and early summer. Majority (>50%) of juveniles believed to rear in tributaries during summer and will have no exposure.
	90 to 245	23	9	
	33 to 90	23	8	
Age 1 juvenile outmigration (Feb 15–March 31, 2020)[a]	1,808 to 4,915	4	10	Major stress, reduced growth, and up to 20% mortality for smolts outmigrating from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (~44% of run). (total of 2,668 smolts, 3% of all populations; impacts vary by population)
	665 to 1,808	6	9	
	245 to 665	12	9	
	90 to 245	20	9	
	33 to 90	18	8	
Age 1 juvenile outmigration (April 1– June 30, 2020)	245 to 665	4	8	Major stress and reduced growth for smolts outmigrating from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (~56% of run).
	90 to 245	19	9	
	33 to 90	17	8	

a maximum migration duration = 20 days

Table E-19. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Coho Salmon for Proposed Action Worst-Case Scenario (10% exceedance probability), for Klamath River at Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1, 2019–Jan 1, 2020)	665 to 1,808	1	8	Major stress and impaired homing for all adults migrating upstream (~4% of all populations exposed).
	245 to 665	7	9	
	90 to 245	13	8	
	33 to 90	34	8	
Spawning, incubation, and fry emergence (Nov 1, 2019–Mar 14, 2020)	4,915 to 13,360	5	12	Effects of suspended sediment on spawning gravel quality were not modeled; however, suspended sediment is predicted to result in nearly 100% mortality of all progeny from mainstem spawning. (~13 redds, or 0.7–26% of Upper Klamath River Population unit natural escapement).
	1,808 to 4,915	26	13	
	665 to 1,808	26	13	
	245 to 665	16	12	
	90 to 245	14	12	
	33 to 90	34	12	
Age-1 juveniles during winter (Nov 15, 2019–Feb 14, 2020)	1,808 to 4,915	24	11	Reduced growth and up to 52% mortality for age 1 juveniles from the 2019 cohort rearing in the mainstem. An unknown but assumed small number of all juveniles (<1%) rear in mainstem during winter.
	665 to 1,808	24	10	
	245 to 665	12	9	
	90 to 245	14	8	
	33 to 90	28	8	
Age-0 juveniles during summer (Mar 15–Nov 14, 2020)	665 to 1,808	4	9	Reduced or no growth for age 0 juveniles from 2019 cohort rearing in mainstem. Majority (>50%) of juveniles believed to rear in tributaries during summer and will have no exposure.
	245 to 665	13	9	
	90 to 245	41	9	
	33 to 90	52	9	
Age 1 juvenile outmigration (Feb 15–March 31, 2020)[a]	4,915 to 13,360	3	10	Major stress, reduced growth, and up to 49% mortality for smolts outmigrating from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (~44% of run). (up to 6,536 smolts, 8% of all populations; impacts vary by population)
	1,808 to 4,915	6	10	
	665 to 1,808	11	10	
	245 to 665	18	9	
	90 to 245	20	9	
	33 to 90	20	8	
Age 1 juvenile outmigration (April 1– June 30, 2020)[a]	665 to 1,808	1	8	Major stress and reduced growth for smolts outmigrating from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (~56% of run).
	245 to 665	12	9	
	90 to 245	20	9	
	33 to 90	20	8	

[a] maximum migration duration = 20 days

Because coho salmon spawning in the mainstem is uncommon (Magneson and Gough 2006), it is unlikely that dam removal will directly affect egg or alevin development, with the exception of any redds in the mainstem. Coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, as well as their progeny, would suffer up to

100 percent mortality under either scenario of the Proposed Action (Table E-18); however, even under existing conditions and the No Action/No Project Alternative, very high mortality (98 to 100 percent) is expected (Table E-6 and E-7) due to the effects of suspended sediment on these life stages (in addition to other sources of mortality); therefore, the effects of suspended sediment resulting from the Proposed Action are within the range of those predicted for existing conditions and the No Action/No Project Alternative. Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), from 6 to 13 redds could be affected, many of which are thought to be hatchery returning fish (NOAAFisheries 2010). Based on the range of escapement estimates of Ackerman et al. (2006), 13 redds could represent anywhere from 0.7 to 26 percent of the naturally returning spawning in the Upper Klamath River Population Unit, and much less than 1 percent of the natural and hatchery returns combined.

Although most (assumed >50 percent) fry rearing is believed to occur in tributaries, age-0 fry are observed outmigrating from tributaries in late spring and early summer. Juvenile coho in the mainstem during the spring and summer following facility removal (2020) would be exposed to concentrations of suspended sediment that will result in major physiological stress and reduced growth (possibly no growth at all) under the Proposed Action (Tables E-18 and E-19), similar to predictions for extreme existing conditions and the No Action/No Project Alternative (Table E-7). These effects, in addition to possible exposure to diseases and the elevated temperatures often recorded in the mainstem Klamath River during summer, could result in high mortality of this cohort for all populations that have some rearing in the mainstem. There could also be indirect effects on marine survival for those fish that survive the summer, but smolt at a smaller size (Bilton et al. 1982, Hemmingsen et al. 1986).

Under existing conditions and the No Action/No Project Alternative, suspended sediment concentrations are typically high during the winter in the mainstem Klamath River, and predicted to cause major stress for a month under both normal and extreme conditions (Table E-7). Under the Proposed Action, age-1 juveniles (progeny of the 2019 cohort) that have either successfully oversummered or moved from tributaries into the mainstem in fall, could be exposed to much higher SSC in the mainstem during the winter of facility removal than under existing conditions and the No Action/No Project Alternative (Table E-7), and may suffer mortality rates of up to 52 percent under a worst-case scenario (Table E-19). However, many juveniles in the mainstem Klamath River appear to migrate to the lower river to rear and may avoid adverse conditions in the mainstem by using tributary or off-channel habitats during winter, thus reducing their exposure and potential mortality (Soto et al. 2009, Hillemeier et al. 2009), consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984, Servizi and Martens 1992). This strategy may be even more pronounced under the even higher SSC expected under the Proposed Action. Overall, it is not known how many juveniles rear in the mainstem during winter, but it is assumed to be a small (<1 percent) proportion of any of the coho salmon populations.

Coho salmon smolts from the 2019 cohort are expected to outmigrate to the ocean beginning in late February, although most natural origin smolts outmigrate to the mainstem Klamath during April and May (Wallace 2004). During migrant trapping studies from 1997–2006 in tributaries upstream of and including Seiad Creek (Horse Creek, Seiad Creek, Shasta River, and Scott River), 44 percent of coho smolts were captured from February 15 to March 31, and 56 percent from April 1 through the end of June (Courter et al. 2008). Once in the mainstem, smolts move downstream fairly quickly (Stutzer et al. 2006). As discussed in detail in Section A.2, this analysis assumes a maximum exposure of 20 days for downstream migration. Under the Proposed Action, concentrations would be higher during spring than under existing conditions and the No Action/No Project Alternative, and smolts outmigrating in early spring (prior to April 1) are likely to suffer up to 60 percent mortality in a worst-case scenario (Table E-19). Smolts outmigrating in late spring (after April 1) will be exposed to lower concentrations, and may experience only slightly worse physiological stress and reduced growth rates compared with existing conditions and the No Action/No Project Alternative, even under a worst-case scenario.

Based on the results of outmigrant trapping by the USFWS (2001) on the mainstem Klamath River compared with trapping in the Trinity River from 1997 to 2000 (USFWS 2010), most (>80 percent) coho smolts originate from the Trinity River and Lower Klamath River populations. For the majority of smolts produced from tributaries downstream of Orleans, effects of the Proposed Action will be similar to existing conditions and the No Action/No Project Alternative by late April (Figure E-4). The overall mortality rates predicted to occur as a result of the Proposed Action vary for each population, and are summarized in Table E-20, based on the average smolt abundance predicted for the 2018 brood year (age 1 smolts in spring 2020). Smolt abundance data are available for the Shasta River, Scott River, and Trinity River populations. Smolt abundance data from all tributaries within the Upper Klamath, Mid-Klamath, Salmon and Lower Klamath River populations is not available, and so smolt production estimates modeled by Courter et al. (2008) were used. Courter et al. (2008) modeled all mainstem and tributary reaches within the Klamath Basin based on available smolt production data and habitat conditions within tributaries, and thus comprise the most complete assessment of potential smolt production available.

Under existing conditions and the No Action/No Project Alternative, coho salmon smolts outmigrating from the Upper Klamath River, Scott River, and Shasta River populations currently have mortality rates (35 to 70 percent) presumably as a result of poor water quality and disease (Beeman et al. 2007, 2008), which, in conjunction with physiological stress and reduced growth resulting from the Proposed Action, could result in even higher mortality in the spring of 2020.

Table E-20. Summary of Predicted Age 1 Coho Salmon Smolt Mortality during Early Spring Outmigration (44% of total smolt abundance) Resulting from the Proposed Action within Coho Salmon Population Units of the Klamath River Watershed.

Population Unit	Estimated Total Smolt Abundance	Estimated mortality					
		Most Likely to Occur Scenario			Worst Case Scenario		
		Mortality (%)	Number of Smolts	Proportion of Population (%)	Mortality (%)	Number of Smolts	Proportion of Population (%)
Upper Klamath River	7,675[a]	20	676	9	49	1,655	22
Shasta River	1,131[b]	20	100	9	49	244	22
Scott River	1,300[b]	20	114	9	49	280	22
Mid-Klamath River	20,211[a]	20	1,779	9	49	4,357	22
Salmon River	4,611[a]	0	0	0	0	0	0
Upper Trinity River	3,122[c]	0	0	0	0	0	0
Lower Trinity River							
South Fork Trinity River							
Lower Klamath River	45,861[a]	0	0	0	0	0	0
Total	83,911		2,668	3		6,536	8

[a] Based on Courter et al. (2008) for an average water year under existing conditions.
[b] California Department of Fish and Game, unpublished data 2011. Predictions for 2018 brood year based on average of brood year 2003, and 2006 smolt production (spring 2005 and 2008).
[c] Based on Scheiff et al. (2001) abundance estimates for natural production.

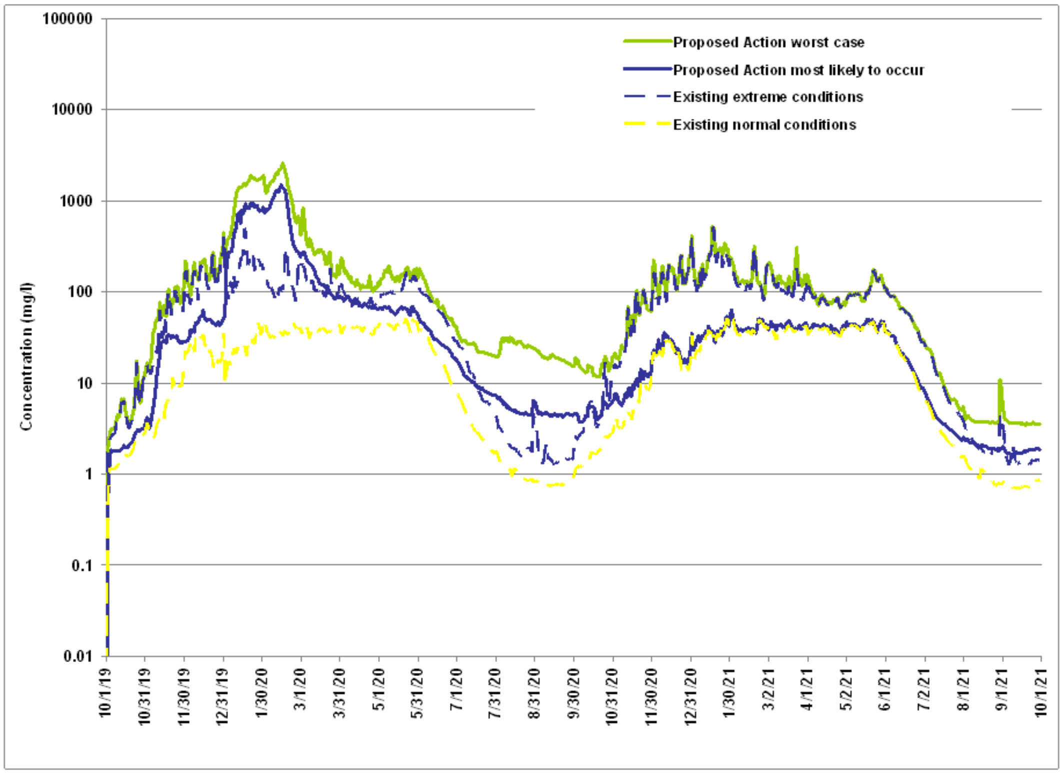

Figure E-4. Proposed Action Compared to Existing Conditions and the No Action/No Project Alternative at Orleans, as Predicted using SRH-1D Model.

E.3.2.4 Summer- and Winter-run Steelhead

Although steelhead do migrate as far upstream as Iron Gate Dam, they are primarily distributed downstream of Seiad Valley; therefore, this analysis focuses on exposure to suspended sediment in the mainstem Klamath River downstream of Seiad Valley.

Adult summer steelhead typically enter and migrate up the Klamath River from March through June (Hopelain 1998). Under the Proposed Action, SSC would be higher than under existing conditions and the No Action/No Project Alternative, most likely resulting in major physiological stress and impaired homing, or up to 20 percent adult mortality under a worst-case scenario. Based on summer steelhead surveys conducted in the Salmon River and other tributaries to the Klamath River by the USDA Forest Service and others from 1985 to 2009, on average around 657 adult summer steelhead migrate up the Klamath River to tributaries upstream of the Trinity River (USDA Forest Service, unpubl. data; Salmon River Restoration Council, unpubl. data), with an additional 800 on average migrating up the Trinity River (Busby et al. 1994). Under the worst case scenario 0 to 20 percent mortality could result from the Proposed Action, resulting in mortality of from 0 to 130 adults, or from 0 to 9 percent of the basin-wide escapement. Those summer steelhead that spawn in the Trinity River (~55 percent of the run based on escapement data) and other downstream tributaries will likely be exposed to only slightly higher impacts from suspended sediment than under existing conditions and the No Action/No Project Alternative.

The Proposed Action is anticipated to have a direct effect on returning adult winter steelhead. Adults enter the Klamath River in late summer and fall, and migrate and hold in the mainstem Klamath River through fall and winter. These adults will likely be exposed to much higher SSC than under existing conditions and the No Action/No Project Alternative (Tables E-21 and E-22). Information on the abundance of winter steelhead, which is considered to be the most abundant form, is very limited due to logistical difficulties in sampling adults during the winter season. The only decent long-term data on adult returns is from hatchery returns to the Iron Gate Hatchery and Trinity River Hatchery (Busby et al. 1994). In a good year around 7,000 adults return to both hatcheries, including around 3,500 to the Klamath River upstream of the Trinity River (Busby et al. 1994). Based on USFWS (1998) periodicities assessment, on average around 80 percent (2,800 fish) of winter steelhead migrate upstream after December 15th, and could be exposed to SSC released from the Proposed Action, although in some years many more fish migrate in the fall before that time. Based on predictions of up to 40 percent mortality of the adult winter run under the most-likely scenario, up to 1,008 adults, or up to 14 percent of the total run could be affected by the Proposed Action. Under the worst-case scenario up to 71 percent mortality is predicted to occur as a result of the Proposed Action, resulting in up to 1,988 adults, or up to 28 percent of the basin-wide escapement. Stressed adults are also assumed to be more susceptible to disease, possibly increasing pre-spawn mortality, unless they respond to the high turbidity by entering tributaries earlier than usual, as was observed for upstream-migrating Chinook and coho salmon during the September 2002 fish kill event in the lower Klamath River (M. Belchik, pers. comm., August 2008). In addition, steelhead are a highly migratory species that regularly occur in environments with high SSCs, and therefore the predictions described here are likely more dire than would occur.

Since no steelhead spawning occurs in the mainstem Klamath River under existing conditions and the No Action/No Project Alternative, the egg, alevin, and fry life stages are not anticipated to be affected by suspended sediment resulting from the Proposed Action (Tables E-21 and E-22).

Post-spawning adults (“runbacks”) migrate downstream in the spring to return to the sea, typically from April through May. Under the Proposed Action, SSC will be higher than under existing conditions and the No Action/No Project Alternative, and sublethal but major stress is likely under either scenario (Tables E-21 and E-22). If runbacks migrate relatively quickly from their spawning tributaries to the ocean, this may overestimate the duration of their exposure to sediment in the mainstem. There are little data on downstream-migrating steelhead in the Klamath with which to understand potential consequences of exposure to suspended sediment during this life-history phase.

Table E-21. Predicted Suspended Sediment Concentrations, Durations, and Anticipated Effects on Steelhead for Proposed Action Most Likely Scenario (50% exceedance probability), Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult summer upstream migrants (Mar 1–June 30, 2020)	665 to 1,808	3	9	Major stress and impaired homing for adult migrants. The ~55% that migrate to the Trinity River or tributaries further downstream will not be as affected.
	245 to 665	10	9	
	90 to 245	25	9	
	33 to 90	18	8	
Adult winter upstream migrants (Aug 1 2019–Mar 31, 2020)	1,808 to 4,915	14	10	Major stress, impaired homing, and up to 36% mortality for adult migrants. (Up to 1,008 adults, or up to 14% of the total escapement).
	665 to 1,808	11	10	
	245 to 665	11	9	
	90 to 245	7	8	
	33 to 90	20	8	
Adult run-backs (Apr 1–May 30, 2020)	245 to 665	1	8	Moderate to major stress to downstream-migrating adults during a two-week period; effect will depend on timing of outmigration in relation to suspended sediment pulse.
	90 to 245	17	8	
	33 to 90	8	7	
Half-pounder residence (Aug 15, 2019–Mar 31, 2020)	245 to 665	2	8	Major stress and potentially impaired homing. Majority remain in tributaries and will not be affected.
	90 to 245	7	8	
	33 to 90	13	7	
Spawning through emergence (Dec 1, 2019–June 1, 2020)	n/a	n/a	n/a	Spawning occurs in tributaries; no effect.
Age 0 juvenile rearing (Mar 15–Nov 14, 2020)	245 to 665	7	9	Major stress and reduced growth. Around 40% rear in tributaries and will not be affected.
	90 to 245	23	9	
	33 to 90	23	8	
Age 1 juvenile rearing (year-round)	1,808 to 4,915	14	11	Major stress resulting in reduced growth and up to 52% mortality. (Up to 8,200 juveniles or around 14% of total age 1 production).
	665 to 1,808	11	10	
	245 to 665	13	9	
	90 to 245	25	9	
	33 to 90	25	8	
Age 2 juvenile rearing (Nov 15, 2019–Mar 31, 2020)	1,808 to 4,915	14	11	Major stress resulting in reduced growth and up to 52% mortality. (Up to 6,893 juveniles or around 13% of total age 2 production).
	665 to 1,808	11	10	
	245 to 665	11	9	
	90 to 245	7	8	
	33 to 90	17	8	
Juvenile/smolt outmigrants (Apr 1–Nov 14, 2020)	245 to 665	4	8	Major stress and reduced growth. Around 57% outmigrate from Trinity River and will have less exposure.
	90 to 245	19	9	
	33 to 90	22	8	

Table E-22. Predicted Suspended Sediment Concentrations, Durations, and Anticipated Effects on Steelhead for Proposed Action Worst-Case Scenario (10% exceedance probability), Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult summer upstream migrants (Mar 1–June 30, 2020)	1,808 to 4,915	<1	9	Major stress, impaired homing, and up to 20% mortality for adult migrants. (From 0 to 130 adults, or from 0 to 9% of the basin-wide escapement).
	665 to 1,808	8	10	
	245 to 665	18	9	
	90 to 245	41	9	
	33 to 90	32	8	
Adult winter upstream migrants (Aug 1 2019–Mar 31, 2020)	4,915 to 13,360	5	11	Major stress, impaired homing, and up to 71% mortality for adult migrants. (Up to 1,988 adults, or up to 28% of the basin-wide escapement).
	1,808 to 4,915	26	11	
	665 to 1,808	26	10	
	245 to 665	17	9	
	90 to 245	20	8	
	33 to 90	34	8	
Adult run-backs (Apr 1–May 30, 2020)	665 to 1,808	1	8	Major stress to downstream-migrating adults.
	245 to 665	10	9	
	90 to 245	32	9	
	33 to 90	25	8	
Half-pounder residence (Aug 15 2019–Mar 31, 2020)	1,808 to 4,915	1	9	Major stress and reduced growth. Majority remain in tributaries and will not be affected.
	665 to 1,808	2	9	
	245 to 665	11	9	
	90 to 245	18	8	
	33 to 90	30	8	
Spawning–fry emergence (Dec 1–Jun 1, 2020)	n/a	n/a	n/a	Spawning occurs in tributaries; no effect.
Age 0 juvenile rearing (Mar 15–Nov 14, 2020)	665 to 1,808	4	9	Major stress and reduced growth. Around 40% rear in tributaries and will not be affected.
	245 to 665	13	9	
	90 to 245	41	9	
	33 to 90	52	9	
Age 1 juvenile rearing (year-round)	4,915 to 13,360	5	11	Major stress resulting in reduced growth and up to 71% mortality. (Up to 11,207 juveniles or around 19% of total age 1 production).
	1,808 to 4,915	26	11	
	665 to 1,808	26	10	
	245 to 665	18	9	
	90 to 245	41	9	
	33 to 90	52	9	

Table E-22. Predicted Suspended Sediment Concentrations, Durations, and Anticipated Effects on Steelhead for Proposed Action Worst-Case Scenario (10% exceedance probability), Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Age 2 juvenile rearing (Nov 15 2019–Mar 31, 2020)	4,915 to 13,360	5	11	Major stress resulting in reduced growth and up to 71% mortality. (Up to 9,412 juveniles or around 18% of total age 2 production).
	1,808 to 4,915	26	11	
	665 to 1,808	26	10	
	245 to 665	17	9	
	90 to 245	20	9	
	33 to 90	28	8	
Juvenile/smolt outmigrants (Apr 1–Nov 14, 2020)	665 to 1,808	1	8	Major stress and reduced growth. Around 57% outmigrate from Trinity River and will have less exposure and no mortality.
	245 to 665	12	9	
	90 to 245	39	9	
	33 to 90	52	9	

Adult summer-run half-pounders typically enter the mainstem and hold from around mid-August through March, and thus would be affected by the Proposed Action during the winter of 2020. Half-pounders in the mainstem upstream of the Trinity River could be exposed to higher SSC than under existing conditions and the No Action/No Project Alternative, with major physiological stress predicted under either scenario (Tables E-21 and E-22). However, an unknown proportion of half-pounders are observed to hold in the Trinity River or other tributaries, and these fish will not be affected.

Juvenile steelhead rear in the mainstem Klamath River, tributaries to the Klamath, or the estuary. Since most (>90 percent) juvenile steelhead smolt at age-2, those juveniles leaving tributaries to rear in the mainstem will be exposed to elevated suspended sediment concentrations resulting from the Proposed Action through both winter and spring. Based on captures in tributaries and the mainstem, it appears than around 40 percent of the population rears in tributaries until age-2 (Scheiff et al. 2001), and will only be susceptible while outmigrating. The approximately 60 percent of the rearing population that outmigrates from tributaries as age-0 or age-1 and rears for extended periods in the mainstem upstream of Trinity River would likely be exposed to much higher SSC than under existing conditions and the No Action/No Project Alternative, with mortality rates up to 100 percent in a worst-case scenario (Tables E-21 and E-22). Table E-23 summarizes the total number of rearing steelhead of each class within the Klamath River estimated based on migrant trapping data from the Trinity River at Willow Creek and the Klamath River at Big Bar from 1997 to 2000 (Scheiff et al. 2001). Mortality estimates in Table E-23 were based on the extrapolated estimates of abundance for each class within the Klamath River, as compared to the average total production estimated in both the Klamath and Trinity river trap locations, and assuming around 40 percent of juveniles rear within tributaries and will not be exposed. This estimate does not consider juveniles produced from tributaries downstream of the Trinity River, and thus the actual rate of mortality would be lower than estimated here. It does appear that many of these juveniles avoid conditions in the mainstem by using tributary and off-channel habitats during winter, which would reduce their exposure (Soto et al. 2009, Hillemeier et al. 2009), consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984, Servizi and Martens 1992). Most smolts outmigrate in the fall, so many juveniles should already be in the estuary or ocean when initial pulses in sediment occur, or they may migrate out of the mainstem later in the winter after concentrations decrease.

Table E-23. Summary of Steelhead Juvenile Rearing Abundance and Estimated Mortality Resulting from the Proposed Action.

	Age 0		Age 1		Age 2 and older	
	Klamath River	Trinity River	Klamath River	Trinity River	Klamath River	Trinity River
Average juvenile abundance	4,217	13,384	15,784	20,445	13,256	17,401
Most-likely to occur scenario						
Estimated mortality rate	0%	0%	52%	0%	52%	0%
Mortality estimate	0	0	8,208	0	6,893	0
Percentage of total production	0%	0%	14%	0%	13%	0%
Worst-case scenario						
Estimated mortality rate	0%	0%	71%	0%	71%	0%
Mortality estimate	0	0	11,207	0	9,412	0
Percentage of total production	0%	0%	19%	0%	18%	0%

Under the Proposed Action, steelhead outmigrating in spring as age-2 smolts from tributaries higher in the basin will likely be exposed to suspended sediment for longer than under existing conditions and the No Action/No Project Alternative, with major physiological stress predicted for both scenarios (Tables E-21 and E-22). Based on migrant trapping data from the Trinity River at Willow Creek and the Klamath River at Big Bar from 1997 to 2000 (Scheiff et al. 2001) approximately 57 percent of smolts outmigrate from the Trinity River, and will be exposed to SSC similar to those under existing conditions and the No Action/No Project Alternative.

E.3.2.5 Pacific lamprey

Based on Pacific lamprey distribution, the impacts of the Proposed Action will be highest on those lamprey returning to or emigrating from mid-Klamath River tributaries such as the Scott River; therefore, this analysis focuses on exposure to suspended sediment in the reach downstream of Seiad Valley.

There is little to no literature on the effects of suspended sediment on lamprey. This analysis used the effects of suspended sediment on salmonids to predict effects on lamprey, with the assumption that effects on lamprey are equivalent or less severe than on salmonids. In general, most life stages of Pacific lamprey appear more resilient to poor water quality conditions than salmonids (Zaroban et al. 1999), so this is likely a conservative assessment of potential effects.

Anadromous Pacific lamprey enter the Klamath Basin throughout the year, although their numbers peak in early winter, and thus a large proportion of adults could be directly effected by suspended sediment resulting from the Proposed Action in winter and early spring, with possibly up to 40 percent mortality under a most-likely scenario, and up to 100 percent under a worst-case scenario (Tables E-24 and E-25). Approximately 44 percent of Pacific lamprey are believed to spawn in the Trinity River basin (Scheiff et al. 2001). These individuals will be exposed to lower SSC, while those adults returning in fall, summer, or late spring will avoid exposure to the highest suspended sediment concentrations likely to result from the Proposed Action.

Pacific lamprey ammocoetes rear for a variable number of years before outmigrating to sea; therefore, suspended sediment resulting from the Proposed Action has the potential to affect multiple year-classes of the population (Tables E-24 and E-25). Lamprey are reported to have an intermediate level of tolerance to increased sedimentation and turbidity (Zaroban et al. 1999), but it is not known how changes in suspended sediment affect ammocoete survival. Juvenile salmonids would have mortality rates of 60-100 percent under a worst-case scenario (Tables E-24 and E-25), but because Pacific lamprey ammocoetes rear in burrows in fine sediment, they may tolerate spikes in suspended sediment resulting from the Proposed Action, although excessive sedimentation from the settling out of suspended fines could possibly smother ammocoetes in some areas. Ammocoetes are filter-feeders, so at a minimum reduced growth rates might be expected from elevated suspended sediment, and it is assumed that mortality will be higher than under existing conditions and the No Action/No Project Alternative. However, the broad spatial distribution of lamprey in the Klamath Basin, including mid-Klamath River tributaries such as the Scott River, and the fact that ~44 percent of adults return to the Trinity River, should mean that a large portion of the rearing ammocoete population will escape impacts from the Proposed Action.

Juvenile lamprey (ages 2 to 10) outmigrate to the ocean from the mainstem Klamath River and tributaries rear-round, with peaks in late spring and fall. Exposure to suspended sediment from the Proposed Action is only slightly higher during the spring migration than under existing conditions and the No Action/No Project Alternative and the same as existing conditions and the No Action/No Project Alternative during fall (Tables E-24 and E-25).

Table E-24. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Pacific lamprey for Proposed Action Most Likely Scenario (50% exceedance probability), for Klamath River at Seiad Valley (RM 12).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migration and spawning (all of 2020)	1,808 to 4,915	14	10	Major stress, reduced growth, and up to 36% mortality for adult migrants. Adults migrating in late spring and summer exposed to lower SSC, as are lamprey returning to lower river tributaries such as the Trinity River.
	665 to 1,808	11	10	
	245 to 665	13	9	
	90 to 245	25	9	
	33 to 90	25	8	
Ammocoete rearing (all of 2020)	1,808 to 4,915	14	11	Major stress, reduced growth, and up to 52% mortality for multiple year classes. Majority rear in tributaries and will not suffer mortality.
	665 to 1,808	11	10	
	245 to 665	13	9	
	90 to 245	25	9	
	33 to 90	25	8	
Spring outmigration (May 1–June 30, 2020)	90 to 245	10	8	Major stress for all juveniles during spring outmigration.
	33 to 90	16	8	
Fall/winter outmigration (Sept 1–Dec 31, 2020)	90 to 245	2	7	Moderate stress for all juveniles during spring outmigration.
	33 to 90	4	7	

Table E-25. Predicted Suspended Sediment Concentration, Exposure Duration, and Anticipated Effects on Pacific Lamprey for Proposed Action Worst-Case Scenario (10% exceedance probability), for Klamath River at Seiad Valley (RM 129).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migration and spawning (all of 2020)	4,915 to 13,360	5	11	Major stress, reduced growth, and up to 71% for adult migrants. Adult migrating during late spring and summer are exposed to lower concentrations of SSC, as are lamprey returning to lower river tributaries such as the Trinity River, and thus should avoid mortality
	1,808 to 4,915	26	11	
	665 to 1,808	26	10	
	245 to 665	18	9	
	90 to 245	41	9	
	33 to 90	52	8	
Ammocoete rearing (all of 2020)	4,915 to 13,360	5	11	Major stress, reduced growth, and up to 71% mortality for multiple year classes. Majority rear in tributaries and will not suffer mortality.
	1,808 to 4,915	26	11	
	665 to 1,808	26	10	
	245 to 665	18	9	
	90 to 245	41	9	
	33 to 90	52	9	
Juvenile spring outmigration (May 1–June 30, 2020)	665 to 1,808	<1	7	Moderate to major stress and reduced growth for all juveniles during spring outmigration
	245 to 665	9	9	
	90 to 245	26	9	
	33 to 90	30	8	
Juvenile fall/winter outmigration (Sept 1 2020–Dec 31, 2020)	665 to 1,808	1	8	Major stress for all juveniles during spring outmigration
	245 to 665	3	8	
	90 to 245	6	8	
	33 to 90	18	8	

E.3.2.6 Green Sturgeon

Based on green sturgeon distribution, the Proposed Action will have the highest potential effect on green sturgeon within the Klamath River downstream of Ishi Pishi Falls (i.e., downstream of the Salmon River and Orleans; RM 66); therefore, this analysis focuses on exposure of green sturgeon to suspended sediment in this reach.

Very little information is available on the effects of suspended sediment on sturgeon. This assessment is based on available information of the effects of suspended sediment on salmonids, with the assumption that effects on sturgeon are equivalent or less severe than on salmonids. Most life stages of sturgeon are more resilient to poor water quality conditions than salmonids, so this is likely a conservative assessment.

Adult green sturgeon enter the Klamath River beginning in mid-March, and under the Proposed Action are likely to be to exposed to long durations of high SSC, that would result in reduced growth and major physiological stress in salmonids under a worst-case scenario for the Proposed Action (Tables E-26 and E-27). Green sturgeon typically go for long periods without feeding during their spawning migration, and generally feed on benthic organisms detected in fine sediments by their sensitive barbels, both of which traits would likely reduce the impacts of suspended sedimentation on the species in terms of feeding ability (EPIC et al. 2001, as cited in CDWR 2003). Green sturgeon in the Klamath River spawn an average of every four years (occasionally males spawn every two years) (McCovey 2010), which is consistent with spawning return intervals observed in the Rogue River (Erickson and Webb 2007; D. Erickson, Fisheries Biologist, Pew Institute for Ocean Science, pers. comm., August 2008). The result of this life history pattern is that up to 75 percent of the mature adult population (as well as 100 percent of sub-adults) can be assumed to be in the ocean during 2020 and avoid effects associated with the Proposed Action.

Another behavior that may influence the effects of the Proposed Action is that green sturgeon appear to forego spawning migrations if environmental conditions are less than optimal (CALFED 2007). Webb and Erickson (2007) observed that some of the mature adults that entered the Rogue River returned downstream without spawning, and this behavior has also been observed in white sturgeon (J. Van Eenennaam, pers. comm., August 2008). Some adults may turn back upon encountering high suspended sediment concentrations resulting from the Proposed Action and not complete their spawning migration, or may enter later in the spring when concentrations are expected to be lower. Such behavior has not been documented in the Klamath River, however (J. Israel, Research Associate, University of California Department of Animal Science, pers. comm., 2008).

Green sturgeon are broadcast spawners that lay thousands of adhesive eggs that settle into the spaces between cobbles (Moyle 2002). The Proposed Action may affect the spawning, egg, and larval stages in a variety of ways, based on the limited information available. It is generally believed that silt can prevents eggs from adhering to one another, reducing egg viability (EPIC et al. 2001, as cited in CDWR 2003). Fine sediment deposition on the channel bed may reduce availability of exposed cobble surfaces for eggs to adhere to, and incubating eggs could be exposed to higher SSC for longer periods than under existing conditions and the No Action/No Project Alternative. Although 100 percent mortality is predicted for salmonids under the Proposed Action (Tables E-26 and E-27), it is also predicted under existing conditions and the No Action/No Project Alternative, and clearly does not occur every year. Fine sediment deposition resulting from the Proposed Action could reduce production from the mainstem to an unknown degree (J. Van Eenennaam, pers. comm., August 2008). Spawning of green sturgeon is common downstream of the confluence with the Trinity River, where SSC should be similar to existing conditions and the No Action/No Project Alternative. Production from the Trinity River, which is estimated to be around 30 percent of total production from the Klamath Basin (Scheiff et al. 2001), will be unaffected by the Proposed Action in 2020. In addition, production from the Salmon

River in 2020, which is occasionally quite high, will be unaffected by the Proposed Action.

Table E-26. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Green Sturgeon for Proposed Action Most Likely Scenario (50% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult migrants (Mar 15–July 15, 2020)	90 to 245	14	8	Major stress for adult migrants and spawners. Around 75% of mature adult population not expected to migrate in 2020.
	33 to 90	28	8	
Incubation and emergence (April 1–Aug15, 2020)	90 to 245	9	11	Up to 76% mortality for all mainstem production. Around 30% of production is from Trinity River, and will be unaffected. Assessment based on salmonid literature, effects likely exaggerated.
	33 to 90	27	12	
Adult post-spawning holding (Jul 15–Nov 15, 2020)	0	0	0	No effects anticipated.
Juvenile rearing (year-round) and outmigration (May 15–Oct 15, 2020)	1,808 to 4,4915	2	9	Reduced growth and up to 20% mortality. Around 30% of juveniles rear in the Trinity River and will not be affected.
	665 to 1,808	17	10	
	245 to 665	9	9	
	90 to 245	18	9	
	33 to 90	28	8	

Table E-27. Predicted Suspended Sediment Concentrations, Exposure Durations, and Anticipated Effects on Green Sturgeon for Proposed Action Worst-Case Scenario (10% exceedance probability), for Klamath River at Orleans (RM 58).

Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult migrants (Mar 15–July 15, 2020)	245 to 665	8	9	Major stress (adults don't feed) for adult migrants and spawners. ~ 75% of adult population not expected to migrate in 2020.
	90 to 245	29	9	
	33 to 90	62	8	
Incubation and emergence (April 1–Aug15, 2020)	245 to 665	6	11	95% mortality for all mainstem production. Around 30% of production is from Trinity River, and will be unaffected. Assessment based on salmonid literature, effects likely exaggerated.
	90 to 245	29	12	
	33 to 90	58	13	
Adult post-spawning holding (July 15–Nov 15, 2020)	90 to 245	2	7	Short duration and relatively low concentrations not expected to result in adverse effects on adults. About 75% of adults remain holding in the mainstem after spawning; remainder migrate to ocean.
	33 to 90	4	7	
Juvenile rearing (year-round) and outmigration (May 15–Oct 15, 2020)	1,808 to 4,915	6	10	Reduced growth and up to 36% mortality. Around 30% of juveniles rear in the Trinity River and will not be affected.
	665 to 1,808	32	10	
	245 to 665	17	9	
	90 to 245	29	9	
	33 to 90	62	9	

After spawning, around 25 percent of green sturgeon return directly back to the ocean (Moyle 2002), and the remainder hold in mainstem pools in the Klamath River from RM 13 to RM 65 through November. Benson et al. (2007) found that after spawning, most sturgeon held in deep pools in the mainstem Klamath and Trinity rivers from June through November for an average of 150–170 days (range = 116–199 days). Benson et al. (2007) reported that the majority of post-spawning adults outmigrated in the fall and winter after summer holding, and appeared to be triggered by increasing discharge. SSC related to the Proposed Action prior to adult downstream migration is predicted to be similar to existing conditions and the No Action/No Project Alternative, with no associated effects anticipated, even under a worst-case scenario.

Juvenile green sturgeon may rear for one to three years in the Klamath River system before they outmigrate to the estuary and ocean (NRC 2004, FERC 2006, CALFED 2007), usually during summer and fall (Emmett et al. 1991, as cited in CALFED 2007). Green sturgeon juveniles are reported to have rapid growth, and are capable of entering the ocean at young ages (Allen and Cech 2007, as cited in Klimley et al. 2007). Rearing for more than one year is rarely observed in the mid-Klamath River (M. Belchik, pers. comm., August 2008), but at least some juveniles may rear for additional months or years in the lower river and the estuary before migrating to the ocean. Under the Proposed

Action, juveniles of the 2019 cohort rearing downstream of Orleans in 2020 are anticipated to be exposed to higher SSC for longer periods than under existing conditions and the No Action/No Project Alternative (Table E-12). These exposures would be expected to result in no growth and up to 40 percent mortality for juvenile salmonids under a worst-case scenario (Tables E-26 and E-27). However, juvenile green sturgeon exposed to high suspended sediment in the Connecticut River showed no apparent physiological stress, despite the fact that several other sturgeon species suffered gill infections during these same events (B. Kynard, pers. comm., 2008). Juvenile rearing is common downstream of the Trinity River, where SSC will be similar to existing conditions and the No Action/No Project Alternative. Juveniles rearing in the Trinity River, which may represent ~30 percent of the total production in the Klamath Basin (Scheiff et al. 2001), will be unaffected by the Proposed Action in 2020. In addition, any juveniles rearing in the Salmon River in 2020, which also occasionally has abundant production, will be unaffected by the Proposed Action.

E.4 Klamath River Estuary

Estuary fish species regularly documented to occur in the Klamath River estuary (Moyle 2002) include:

- Pacific herring (*Clupea pallasii*)
- Longfin smelt (*Spirinchus thaleichthys*)
- Eulachon (*Thaleichthys pacificus*)
- Topsmelt (*Atherinops affinis*)
- Shiner perch (*Cymatogaster aggregata*)
- Arrow goby (*Clevelandia ios*)
- Starry flounder (*Platichthys stellatus*)

Under existing conditions and the No Action/No Project Alternative, SSC within the Klamath River Estuary is relatively high, the lower Klamath River downstream of the Trinity River confluence (RM 40.0) to the estuary mouth (RM 0.0) is currently listed as sediment impaired under Section 303(d) of the Clean Water Act, as related to protection of the cold freshwater habitat (COLD) beneficial use associated with salmonids (SWRCB 2006, NCRWQCB 2010) (Section 3.2.3.3). Under the Proposed Action sediment will be released from Iron Gate Dam, and will decline in concentration in the downstream direction as a result of accretion from downstream tributaries. As a result, the magnitude of SSC from the Proposed Action relative to existing conditions and the No Action/No Project Alternative is at its lowest level in the Klamath River Estuary (Figure E-5). Therefore effects on aquatic species from SSC within the estuary are not anticipated to be distinguishable from existing conditions and the No Action/No Project Alternative.

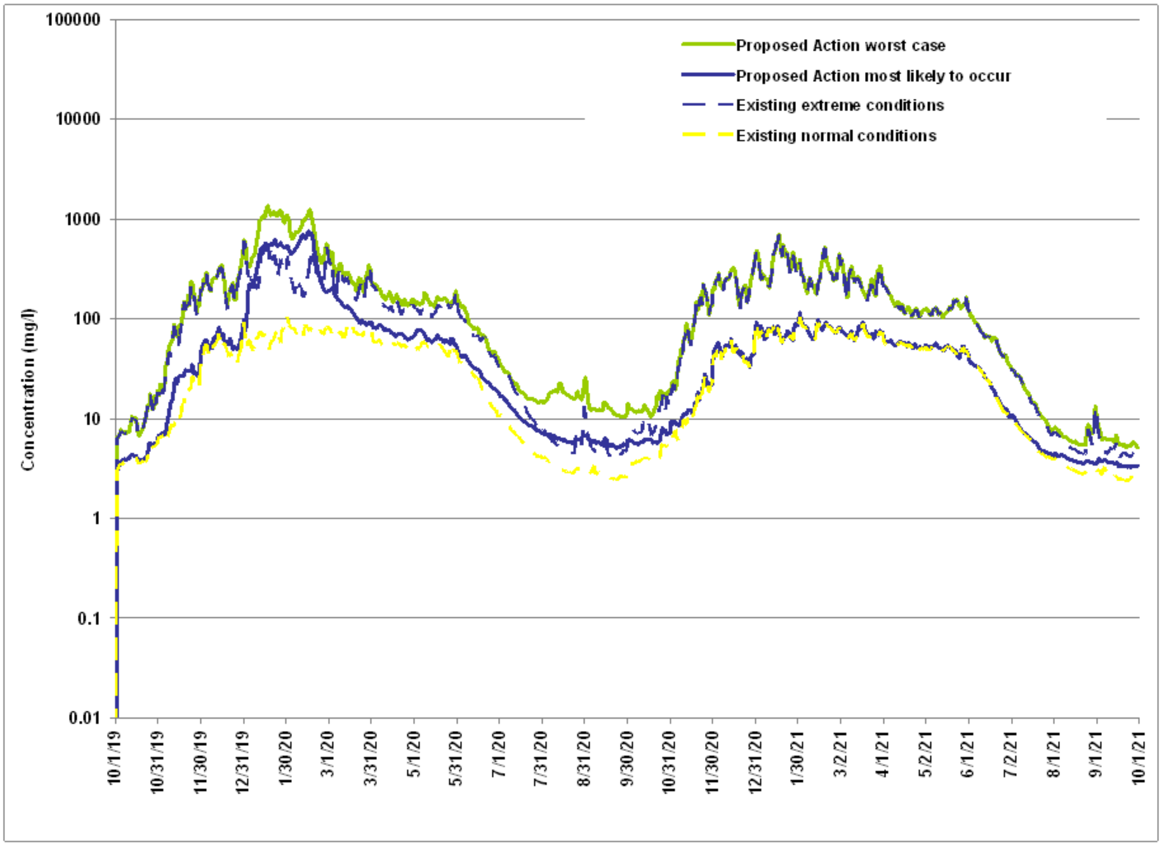

Figure E-5. Comparison of SSC at Klamath Station (RM 5) under Existing Conditions and the Proposed Action, as Predicted Using SRH-1D Model.

E.5 Pacific Ocean near Shore Environment

Many aquatic species occur within the nearshore environment in the vicinity of the Klamath River. Under existing conditions there exists a “plume” within the nearshore environment in the vicinity of the Klamath River that is subject to strong land runoff effects following winter rainfall events. This includes low-salinity, high levels of suspended particles, high sedimentation, and low light (and potential exposure to land-derived contaminants). The extent and shape of plume is variable, and influenced by wind patterns, upwelling effects, shoreline topography (especially Point Saint George), and alongshore currents. High SSC events contribute to the plume, especially during floods (Figure E-6). In a study of the Eel River nearshore sediment plume, located approximately 80 miles to the south of the Klamath River, *in situ* measurements of plume characteristics indicated no relationship with suspended sediment concentration, turbulent-kinetic-energy, time from river mouth, wind speed, wave height, or discharge (Curran et al. 2002). A relationship apparently did exist between effective settling velocity (bulk mean settling velocity) of plume sediments and wind speed/direction, as well as with tides (Curran et al. 2002). In contrast to the lower Klamath River, modeled short-term suspended sediment concentrations following dam removal are not available for the nearshore marine environment adjacent to the Klamath River. Substantial dilution of the high (>1,000 mg/L) mainstem river suspended sediment concentrations is expected to occur in the nearshore under the Proposed Action; based on data from 110 coastal watersheds in California [1], where nearshore SSC were measured at >100 mg/L during the El Nino winter of 1998 (Mertes and Warrick 2001), peak SSC leaving the Klamath River estuary may be diluted by 1-2 orders of magnitude from >1,000 mg/L to >10-100 mg/L. However, considering that dilution of high wintertime SSC loads occurs under existing conditions as well, the magnitude and extent of the sediment plume under the Proposed Action is likely to be greater than that of the No Action/No Project Alternative. This would potentially increase the rate of sediment deposition to nearshore benthic sediments. Overall, any elevations in SSC associated with the Proposed Action are not anticipated to have effects on species distinguishable from existing conditions.

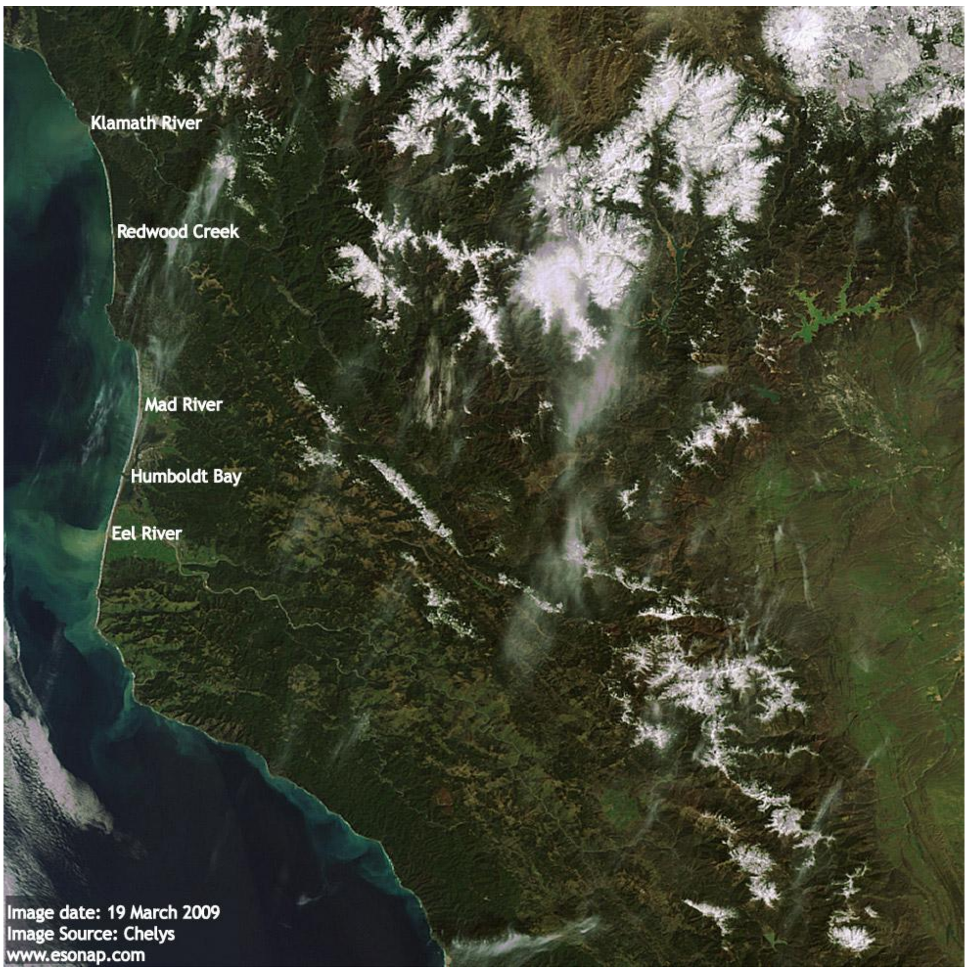

Figure E-6. River Plumes for Rivers in the Vicinity of the Klamath River during Typical Winter Conditions.

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Appendix F
An Analysis of Potential Bedload Sediment Effects on Anadromous Fish in the Klamath Basin

F.1 Introduction

This appendix describes current habitat conditions and assesses the changes to bedload sediment within analysis areas described in Section 3.3 (Aquatic Resources) and under each Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report alternative described in Chapter 2 (Project Description).

F.2 Methods

The effects analysis relied upon output from the Sediment and River Hydraulics-1 Dimension (SRH-1D) model, Version 2.4 (Huang and Greimann 2010) to estimate the spatial and temporal patterns of dam released sediment and sediment resupply from upstream on bed elevation and bed substrate (percent composition of fines [more than 0.063 mm] sand [0.063 to 2 mm], gravel [2 to 64 mm], and cobble [64 to 256 mm; median substrate size [D50]). The model examined short-term (2-year) changes by month under scenarios of two consecutive wet, median, and dry years (i.e., wet-wet [wet simulation], median-median [median simulation], and dry-dry [dry simulation] years), and longer term changes (5, 10, 25, and 50 years) using a range of flows taken from historical hydrology. A long-term simulation was not conducted for the Klamath River upstream of Iron Gate Dam under the assumption that the gradations at the end of two years are representative and will persist through time, allowing for mild fluctuations as a function of hydrology (Bureau of Reclamation [Reclamation] 2011, David Varyu, personal communication January 4, 2011). The effects determination used conclusions from the analysis and knowledge of habitat requirements of affected fish species to determine how changes in bed elevation and substrate would potentially impact aquatic resources (e.g., pool habitat, spawning gravel, benthic habitat).

Dam released sediment and sediment resupply may affect riverine spawning habitat. Increased levels of fine sediment can also reduce median substrate size below that usable for salmonids. Excessive amounts of fine sediment occupying interstitial spaces within spawning gravel can impede intragravel flow, preventing exchange of nutrients and dissolved oxygen between the water column and salmonid embryos, and fill interstitial spaces that impede the emergence of alevins thereby reducing survival (Chapman 1988, Bjornn and Reiser 1991). Studies vary on the size of sediment impeding intragravel flow and blocking emergence, but typically, the sizes vary between 1 and 10 mm (Kondolf 2000). A review by Kondolf (2000) found that 10 to 40 percent fine sediment (ranging in size from 2 to 10 mm) within spawning gravels corresponded to 50 percent survival to emergence of various salmonid species. For example, Bjornn and Reiser (1991) summarized the effects of increasing levels of sediment less than 6.35 mm in the bed on salmonid incubation and found embryo survival and survival to emergence largely unaffected at levels less than 20 percent (98 percent and 70 to 95 percent, respectively). Levels more than 30 percent showed minor effect on embryo survival (90 percent), but greater effects on survival to emergence (10 to 60 percent). The proportion (percent) of sand within the bed and median substrate size, as estimated by SRH-1D, was used to estimate the potential effect of the Proposed Action on salmonid spawning success in specific reaches under short-term and long-term simulations. Beds comprised of less than 20 percent sand and D50 within observed suitable ranges of spawning gravel sizes (e.g., 16 to 70 mm for Chinook salmon [Kondolf and Wolman 1993]), were assumed to provide suitable habitat for salmonid spawning, while more than 20 percent sand along with D50 outside observed ranges of spawning gravel sizes were assumed to provide unsuitable conditions. Changes in substrate composition occurring as a result of dam removal that changed habitat from suitable to unsuitable were assumed to have an adverse impact on salmonids.

F.3 Affected Environment

F.3.1 Upper Klamath River: upstream of the influence of J.C. Boyle Reservoir

Bedload conditions in this region of the area of analysis are not expected to be affected by the Klamath Hydroelectric Settlement Agreement. The existing dams (Link and Keno dams) would remain in place and continue to affect hydrology and sediment transport in much the way they do currently.

For practical purposes, no sediment is supplied to the Klamath River from the basin upstream of Keno Dam (Reclamation 2011). Upper Klamath Lake, with its large surface area, traps nearly all sediment delivered from upstream tributaries. All fluvial sediment supplied to reaches downstream of Iron Gate Dam is delivered to the Klamath River between Keno Dam and Iron Gate Dam. Sources within this reach supply 24,160 tons/yr of coarse sediment (1.3 percent of the cumulative average annual basin-wide coarse sediment delivery) (Stillwater Sciences 2010a).

F.3.2 Hydroelectric Reach from upstream end of J.C. Boyle Reservoir to Iron Gate Dam

The project reservoirs are the dominant feature in this 38 mile (River Mile [RM] 228.3 to RM 190.1) reach, with a 22-mile riverine section between J.C. Boyle Dam (RM 224.1 and the upstream end of Copco 1 Reservoir (203.1) and a 1.5-mile riverine reach between Copco 2 Dam (RM 198.3) and the upstream end of Iron Gate Reservoir (RM 196.9). The four project dams currently store 13,150,000 cubic yards of sediment (3,605,000 tons)

(Reclamation 2011), with Copco 1 Reservoir storing the largest amount and J.C. Boyle Reservoir storing the least (Table F-1). The sediment stored within dams has a high water content and 85 percent of the particles are silts and clays (less than 0.063 mm) while 15 percent are sand or coarser (>0.063 mm) (Gathard Engineering Consulting [GEC] 2006, Stillwater Sciences 2008, Reclamation 2011).

Table F-1. Estimated Volume (yd^3) and Mass (Tons) of Sediment Currently Stored within Hydroelectric Reach Reservoirs

Reservoir	Current Sediment Volume (yd^3)	Current Sediment Mass (tons)
J.C. Boyle	1,000,000	287,000
Copco 1	7,440,000	1,884,000
Copco 2	0	0
Iron Gate	4,710,000	1,434,000
Total	13,150,000	3,605,000

Source: Reclamation 2011

F.3.3 Lower Klamath River: Downstream of Iron Gate Dam

Downstream of Iron Gate Dam, channel conditions reflect the interruption of sediment flux from upstream by project dams and the eventual resupply of sediment from tributaries entering the mainstem Klamath River (PacifiCorp 2004, Reclamation 2011). The reach from Iron Gate Dam to Cottonwood Creek (RM 190.1 to RM 182.1) is characterized by coarse cobble-boulder bars immediately downstream of the dam transitioning to a cobble bed with pool-riffle morphology farther downstream near Cottonwood Creek (Montgomery and Buffington 1996, PacifiCorp 2004, Stillwater Sciences 2010a). Fine sediment input from tributaries locally decreases sediment size distribution in the mainstem Klamath River, but the effect is temporary, as the bed coarsens before the next tributary junction (PacifiCorp 2004). For example, median grain size at the confluence of Bogus Creek and the Klamath River is 47 mm, but downstream the bed coarsens to a median grain size of 96 mm (PacifiCorp 2004). Cottonwood Creek to the Scott River (RM 182.1 to RM 143.0) is a confined channel with a cobble-gravel bed and pool-riffle morphology (PacifiCorp 2004). The median bed material ranges from 45 to 50 mm, but bar substrates become finer in the downstream direction, with median sizes of 49 mm and 25 mm at the upstream and downstream ends, respectively. Downstream of the Scott River, including through the Seiad Valley, the Klamath River is cobble-gravel bedded with pool-riffle morphology (PacifiCorp 2004). PacifiCorp (2004) also noted increasing quantities of sand and fine gravel on the bed surface with distance downstream, likely reflecting the resupply of finer material from tributaries to the Klamath River.

The project dams trap most coarse sediment produced in the low sediment yield, young volcanic terrain, upstream of the dams. This results in coarsening of the channel bed downstream of the dams until tributaries re-supply the channel with finer sediment. However, most of the supply from the portion of the watershed upstream of J.C. Boyle Reservoir is trapped in Upper Klamath Lake, which is a natural lake. Most of the sediment supplied to the mainstem Klamath River (~98 percent; Stillwater Sciences 2010a) is delivered from tributaries downstream of Cottonwood Creek, limiting the effects of interrupting upstream sediment supply. Analysis of the area and number of gravel bars and terraces downstream of Iron Gate Dam suggests that the influence of the project dams on these alluvial features, which are sources of salmonid spawning gravel, is limited to the reach from Iron Gate Dam to Cottonwood Creek (PacifiCorp 2004). This effect is almost entirely absent downstream of the Shasta River, and is undetectable as the Klamath River flows through the Seiad Valley (PacifiCorp 2004).

F.4 No Action/No Project Alternative

F.4.1 Hydroelectric Reach: from upstream end of J.C. Boyle Reservoir to Iron Gate Dam

Under the No Action/No Project Alternative, project dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Stillwater Sciences (2010a) estimates that 100,600 yd^3/yr (151,000 tons/yr assuming 1.5 tons/yd) of sediment is delivered to the Klamath River between Keno and Iron Gate Dams. A portion of the fine (less than 0.063 mm; 84,560 yd^3/yr) and all of the coarse (>0.063 mm; sediment load (16,107 yd^3/yr) loads would deposit within the project reservoirs. Reclamation (2011) estimates project reservoirs would store 23,500,000 yd^3 of fine and coarse sediment by 2061. As reservoir capacities decrease (i.e., as they fill with sediment), trap efficiency may decrease, or sedimentation may cease, allowing sediment to pass through pools.

Under the No Action/No Project Alternative, anadromous fish would not have access to this reach, as is currently the case. Impacts would be confined to riverine (redband trout, shortnose and Lost River suckers), and nonnative reservoir fish.

F.4.1.1 Redband Trout

Redband trout are found within the Hydroelectric Reach, migrating between tributaries and reservoirs to complete their lifecycle (Hamilton et al. 2010). The No Action/No Project Alternative would decrease reservoir capacity, as dams within the Hydroelectric Reach would continue to interrupt downstream sediment transport and store sediment delivered from upstream. The decrease in reservoir volume is expected to have negative long-term impact on redband trout habitat within the Hydroelectric Reach.

F.4.1.2 Lost River and Shortnose Suckers

Federally endangered Lost River and shortnose suckers are found within the Hydroelectric Reach. Similar to redband trout above, the No Action/No Project Alternative is expected to reduce habitat area as dams continue to trap sediment transported from upstream. However, there is little or no successful reproduction of either sucker species downstream of Keno Dam and both contribute minimally to conservation goals or significantly to recovery (Hamilton et al. 2010). Thus, although reduction in habitat would have negative long-term impact on Lost River and shortnose sucker habitat in the Hydroelectric Reach, the overall impact to the population would be less than significant.

F.4.1.3 Nonnative Reservoir Fish

As discussed above, the No Action/No Project Alternative would decrease the amount of reservoir habitat as dams continue to interrupt downstream sediment transport. This reduction in reservoir volume is expected to have a negative long-term impact on habitat for nonnative reservoir fish.

F.4.2 Lower Klamath River: Downstream of Iron Gate Dam

The channel directly downstream of Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment is resupplied by tributary inputs (Hetrick et al. 2010, Stillwater Sciences 2010a). The downstream extent of the effect of project dams on sediment supply (and channel condition) would be substantially reduced at the Cottonwood Creek confluence (PacifiCorp 2004). The bed material just downstream of Iron Gate Dam is coarser than would be expected due to the interruption of fine and coarse sediment supply from upstream (Reclamation 2011). The coarser bed material is mobilized at higher flows that occur less frequently, resulting in channel features that are more stable.

F.4.2.1 Fall-Run Chinook Salmon

The distribution of fall-run Chinook salmon would continue to be limited by Iron Gate Dam. Under the No Action/No Project Alternative, the bed immediately below Iron Gate Dam would continue to coarsen, which would result in worsening conditions for spawning in this reach. There would be no change in bed elevation or in habitat composition. Because of the limited amount of habitat affected (Iron Gate Dam [RM 190.1] to Cottonwood Creek [RM 182.1]), the impact described above, taken by itself, would not be expected to substantially affect fall-run Chinook salmon populations.

F.4.2.2 Spring-Run Chinook Salmon

Habitat relating to bedload movement within the current distribution of spring-run Chinook salmon would not change under the No Action/No Project Alternative, and thus would not affect this species.

F.4.2.3 Coho Salmon

Coho salmon use the Klamath River upstream as far as Iron Gate Dam, but the vast majority of spawning occurs on the tributaries. For those coho that do use the mainstem for spawning bed coarsening under the No Action/No Project Alternative would further decrease the suitability of the mainstem for spawning. Given the small proportion of coho that use the mainstem, this effect, by itself, would be unlikely to substantially affect the population.

F.4.2.4 Summer Steelhead

The habitat changes relating to bedload movement under the No Action/No Project Alternative would not overlap with the habitat of summer steelhead. Therefore, this alternative would not affect this species.

F.4.2.5 Winter Steelhead

Winter steelhead are currently distributed throughout the Klamath River upstream to Iron Gate dam, but spawn and rear in the tributaries (Federal Energy Regulatory Commission [FERC] 2007). There is no record of winter steelhead spawning in the mainstem Klamath River, which is used mainly as a migration corridor for adults and juveniles (Stillwater Sciences 2010). Therefore, they would not be affected by the bed coarsening that would occur under the No Action/No Project Alternative.

F.4.2.6 Green Sturgeon

The habitat changes relating to bedload movement under the No Action/No Project Alternative would not overlap with the habitat of green sturgeon. Therefore, this alternative would not affect this species.

F.4.3 Klamath River Estuary

As discussed above, the downstream extent of the effect of dams in the Hydroelectric Reach on sediment supply (and channel condition) would be substantially reduced below the Cottonwood Creek confluence, and largely absent downstream of the Shasta River (RM 176.7) (PacifiCorp 2004). There would be no bedload related impacts to aquatic species in the Klamath River Estuary Reach under the No Action/No Project Alternative.

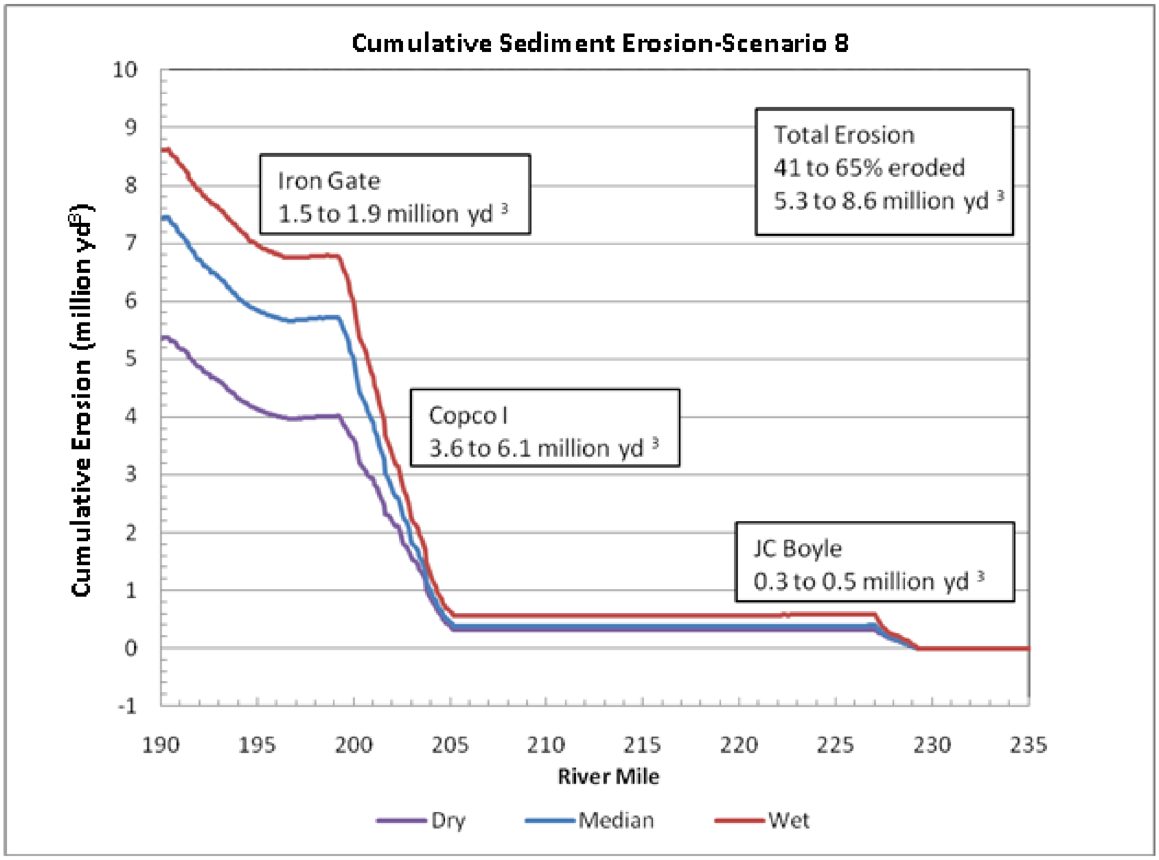
F.4.4 Pacific Ocean Near Shore Environment

As discussed above, the downstream extent of the effect of dams in the Hydroelectric Reach on sediment supply (and channel condition) would be substantially reduced at the Cottonwood Creek confluence, and largely absent downstream of the Shasta River (PacifiCorp 2004). There would be no bedload related impacts to aquatic species in the Pacific Ocean near the shore environment under the No Action/No Project Alternative.

F.5 Proposed Action - Full Facilities Removal of Four Dams

F.5.1 Hydroelectric (Hydro) Reach: from upstream end of J.C. Boyle Reservoir to Iron Gate Dam

Dams in the Hydroelectric Reach currently store 13,150,000 y^3 (3,605,000 tons) of sediment (Table F-1) (Reclamation 2011). No sediment is stored within the Copco 2 Reservoir, but Copco 1 Reservoir stores the greatest amount, and J.C. Boyle Reservoir stores the least. The SRH-1D model estimated 41 to 65 percent (5,300,000 to 8,600,000 yd[3] [1,400,000 to 2,600,000 tons]) of dam stored sediment would be eroded the first year after dam removal depending on simulation type (wet, median or dry) (Figure F-1). Sediment not eroded from the reservoirs during the first year would be stored in gravel bars and terraces, and released more slowly through surficial and fluvial processes (Stillwater Sciences 2008).



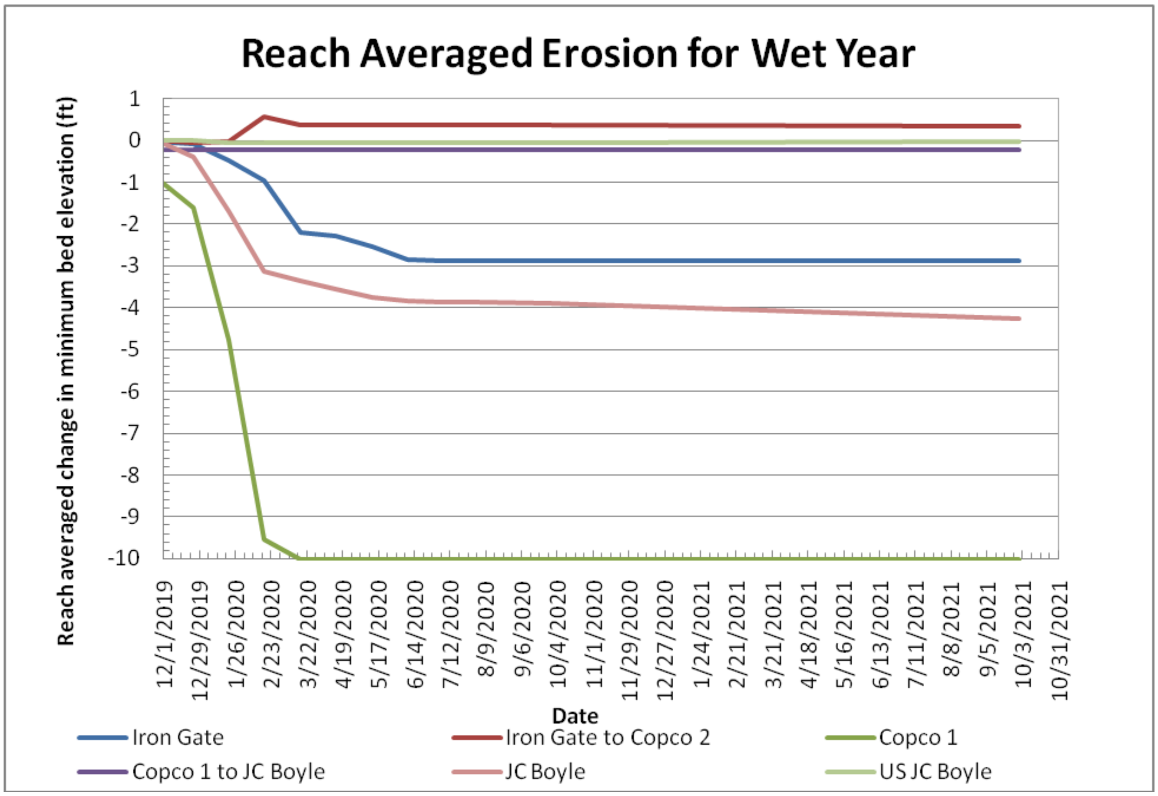
Source: Reclamation 2011.

Figure F-1. Cumulative Sediment Erosion from Dams in the Hydroelectric Reach during Drawdown Beginning January 2020

F.5.1.1 Changes in Bed Elevation

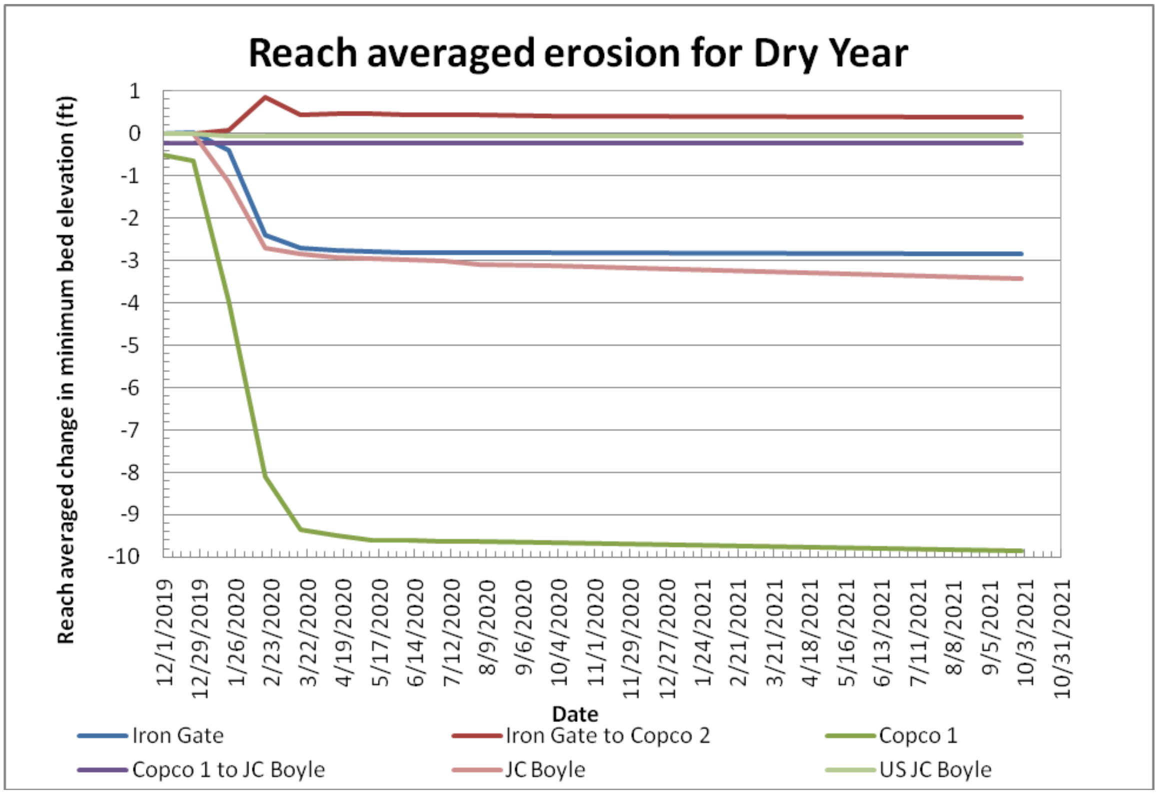
SRH-1D data show substantial decreases in bed elevation within the reservoirs during drawdown (January 2020 to April 2020), which stabilizes as the bed within the historic river channel reaches pre-dam elevations (Reclamation 2011; Blair Greimann, personal communication 23 December 2010). In all simulations, the greatest decrease in bed elevation occurs through the Copco 1 Reservoir (10 ft of erosion), followed by J.C. Boyle Reservoir (3-4 ft), and Iron Gate Reservoir (3 ft) (Figure F-2 and Figure F-3). Draining J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs and erosion of the accumulated sediment is expected to result in the river channels within reservoirs reaching their pre-dam elevations within 4 months. These sections of the river would revert to and maintain a pool-riffle morphology, similar to that existing in reach downstream of Iron Gate Dam, due to restoration of fluvial geomorphic processes (PacifiCorp 2004).

The river reaches between the reservoirs from Copco 1 Reservoir to J.C. Boyle Dam and from Iron Gate Reservoir to Copco 2 Dam show little change during the wet and dry simulations (Figure F-2 and Figure F-3). Both simulations indicate some minimal deposition between Iron Gate Reservoir and Copco 2 Dam, but little change in the other two riverine reaches (Figure F-2 and Figure F-3). Upstream of J.C. Boyle Reservoir (US J.C. Boyle) is also shown in Figure F-2 and Figure F-3, but is part of the Upper Klamath Basin above J.C. Boyle Reservoir reach. Nonetheless, model simulations indicate little, if any change in this portion of the Klamath River.



Source: Reclamation 2011.

Figure F-2. Reach Averaged Erosion in the Hydroelectric Reach during Wet Year

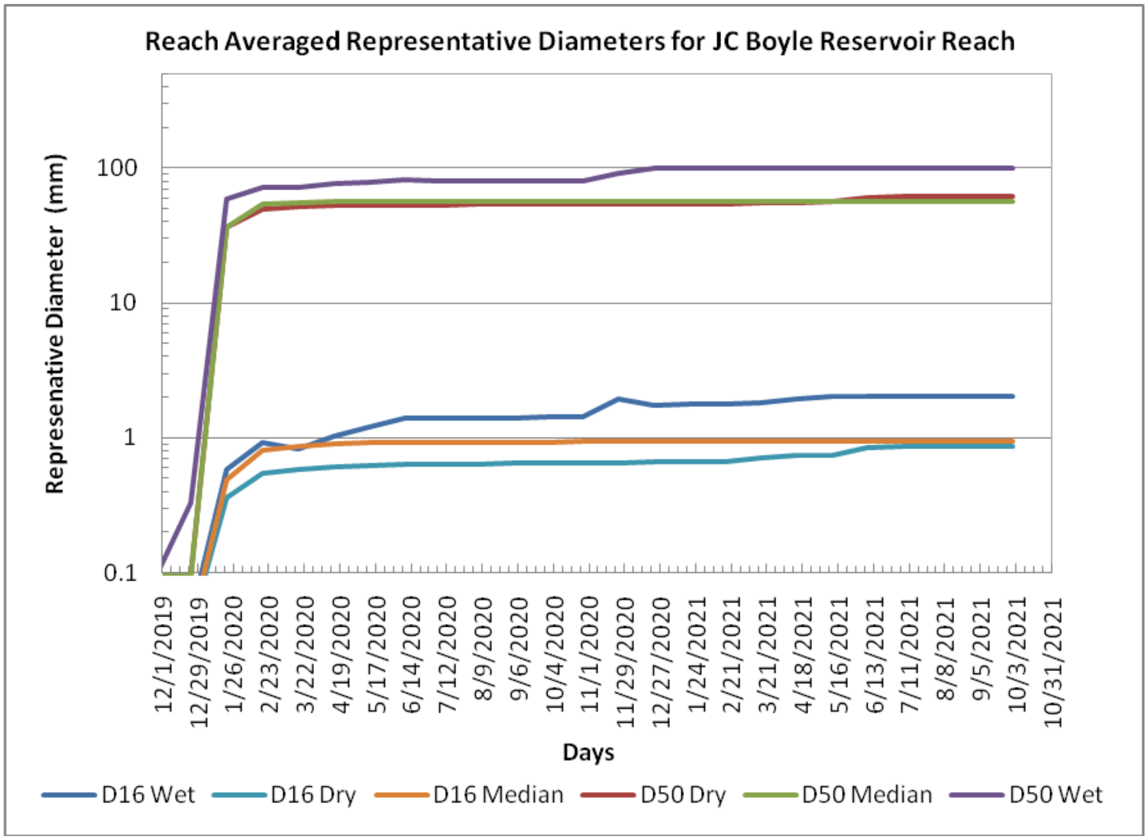


Source: Reclamation 2011.

Figure F-3. Reach Averaged Erosion in the Hydroelectric Reach during Dry Year

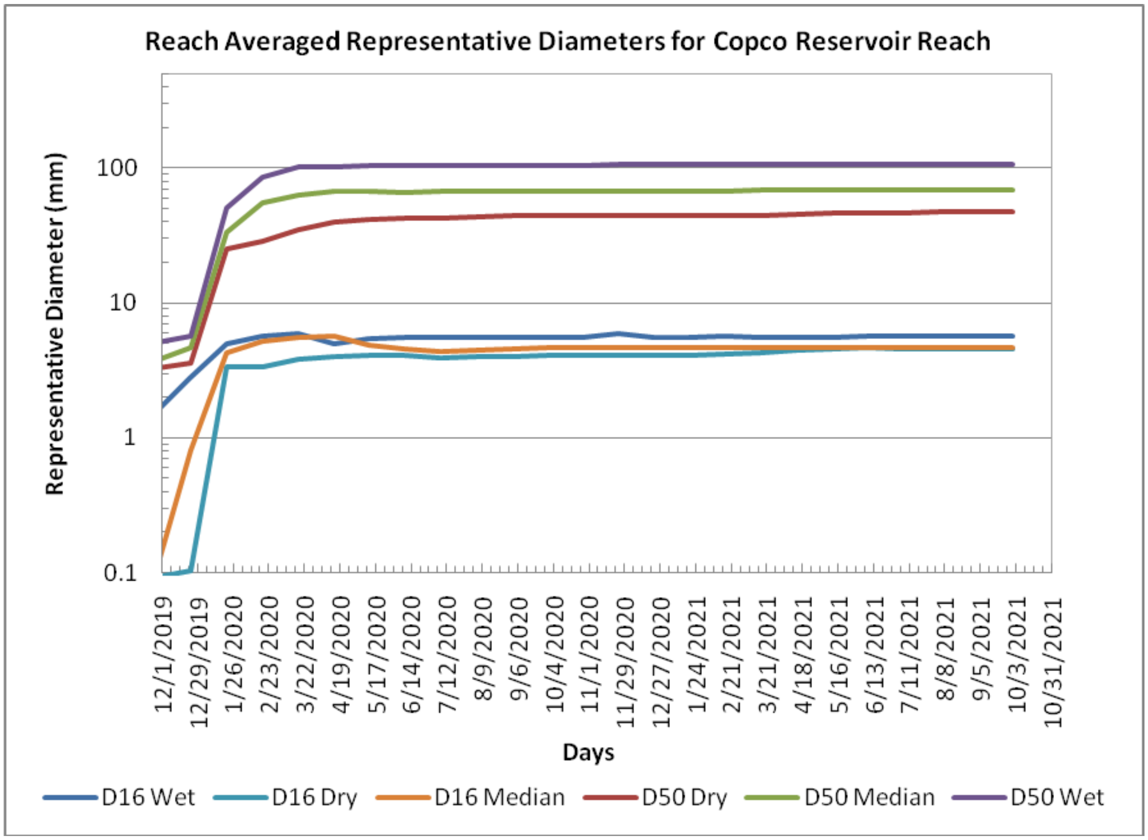
F.5.1.2 Changes in Bed Substrate

Within the reservoirs, SRH-1D modeling data for the first two years after dam removal show decreases in fine sediment and increases in median substrate size after drawdown that stabilize as the bed returns to pre-dam elevation. The proportion of fine sediment decreases from 50 to 80 percent to near zero within 2 months after drawdown, while the proportions of sand, gravel, and cobble increase to 20 to 40 percent, 20 to 30 percent, and 30 to 60 percent, respectively, depending on the reservoir and simulation type (i.e., wet, median, or dry) (Attachment F-1, Figures F1-1 to F1-9). D50s increase from less than 1 mm to sizes ranging from large gravel (32 to 64 mm) to small cobble (64 to 128 mm) (Figure F-4, Figure F-5, and Figure F-6) (Reclamation 2011). D50s may be slightly finer under the dry scenario, but are expected to approach wet and median scenario D50s over time (Reclamation 2011). The D16 (the size at which 16 percent of all particles are finer) shows similar patterns of increase and stabilization during drawdown, but remains sand or finer (less than 2 mm) under the dry and median simulations in the J.C. Boyle and Iron Gate Reservoir reaches (Figure F-4 and Figure F-6) (Reclamation 2011).



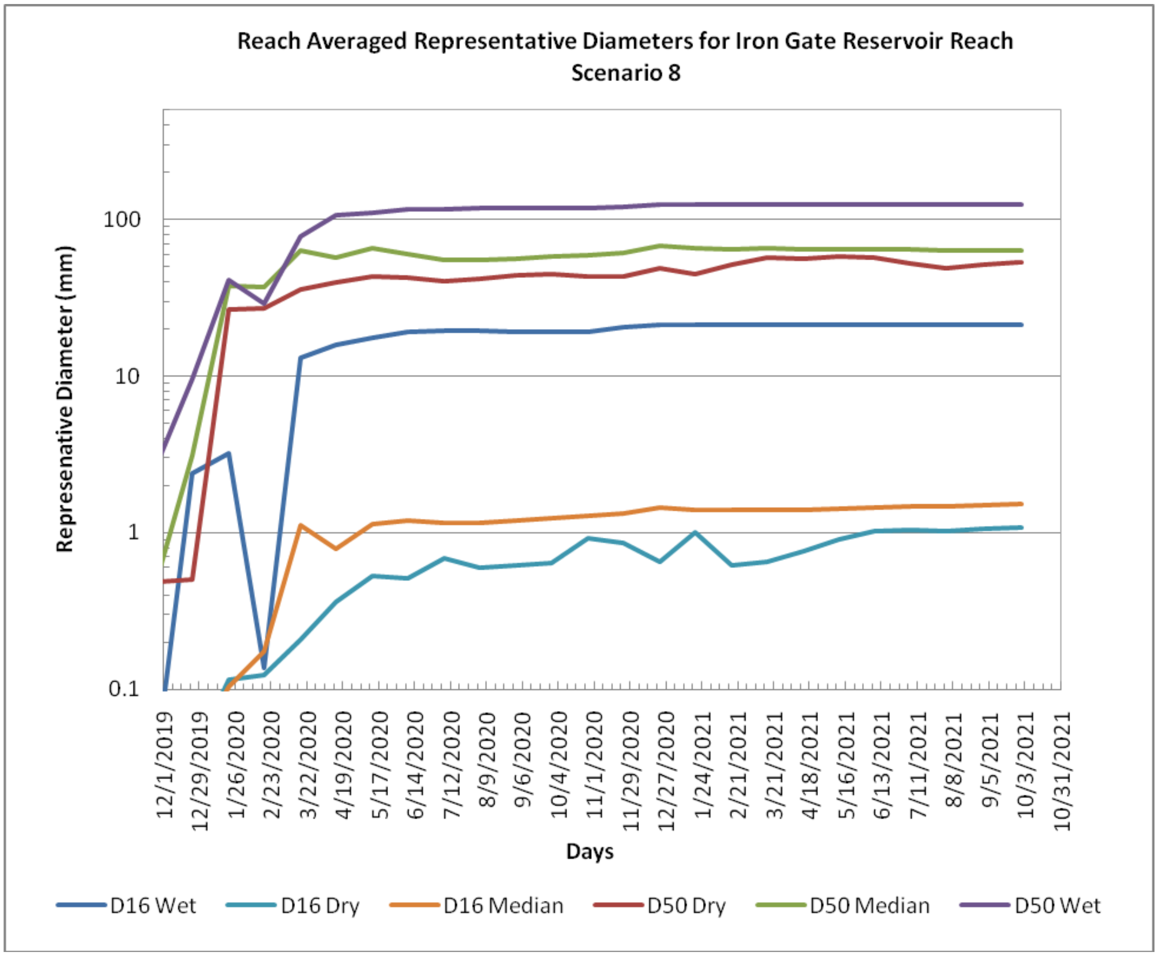
Source: Reclamation 2011.

Figure F-4. Reach Averaged D16 and D50 in J.C. Boyle Reservoir Reach Following Dam Removal



Source: Reclamation 2011.

Figure F-5. Reach Averaged D16 and D50 in Copco Reservoir Reach Following Dam Removal



Source: Reclamation 2011.

Figure F-6. Reach Averaged D16 and D50 in Iron Gate Reservoir Reach Following Dam Removal

The river reaches upstream of J.C. Boyle Reservoir and from Copco 1 Reservoir to J.C. Boyle Dam show little change in bed composition during drawdown. There is practically no temporal change in bed material in response to drawdown regardless of water year upstream of J.C. Boyle Reservoir and from J.C. Boyle Dam to Copco 1 Reservoir (Attachment F-1, Figures F1-10 to F1-15). These reaches are initially predominantly cobble (90 percent) with small fractions of gravel and sand and this composition is maintained throughout the 2-yr simulation.

The Copco 2 Dam to Iron Gate Reservoir reach shows increases in the proportion of sand to 35 to 45 percent shortly after drawdown (from January 2020 to February 2020) (Figure F-7, Figure F-8, and Figure F-9). The wet simulation shows decreases to less than 10 percent after February 2020 that continue through the end of two years, while the median simulation slowly decreases to 10 percent by July 2020 (Figure F-7 and Figure F-8). In the dry simulation, the percent sand decreases to 20 percent from

April 2020 to February 2021, then again to 10 percent from February 2021 to the end of the simulation (Figure F-9).

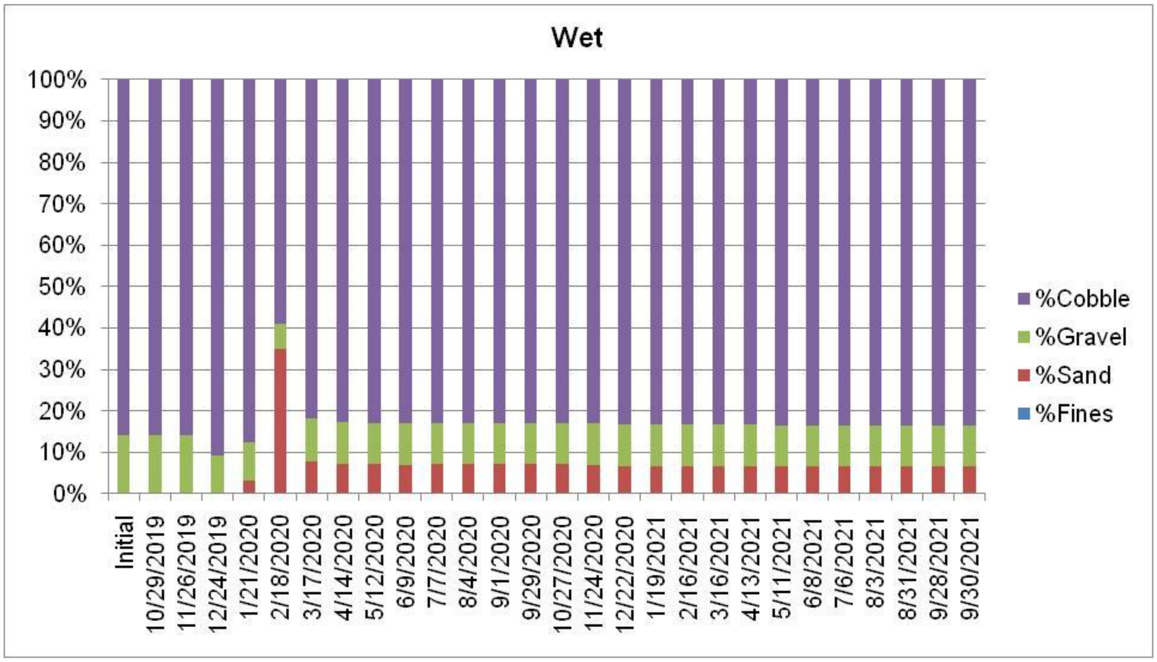
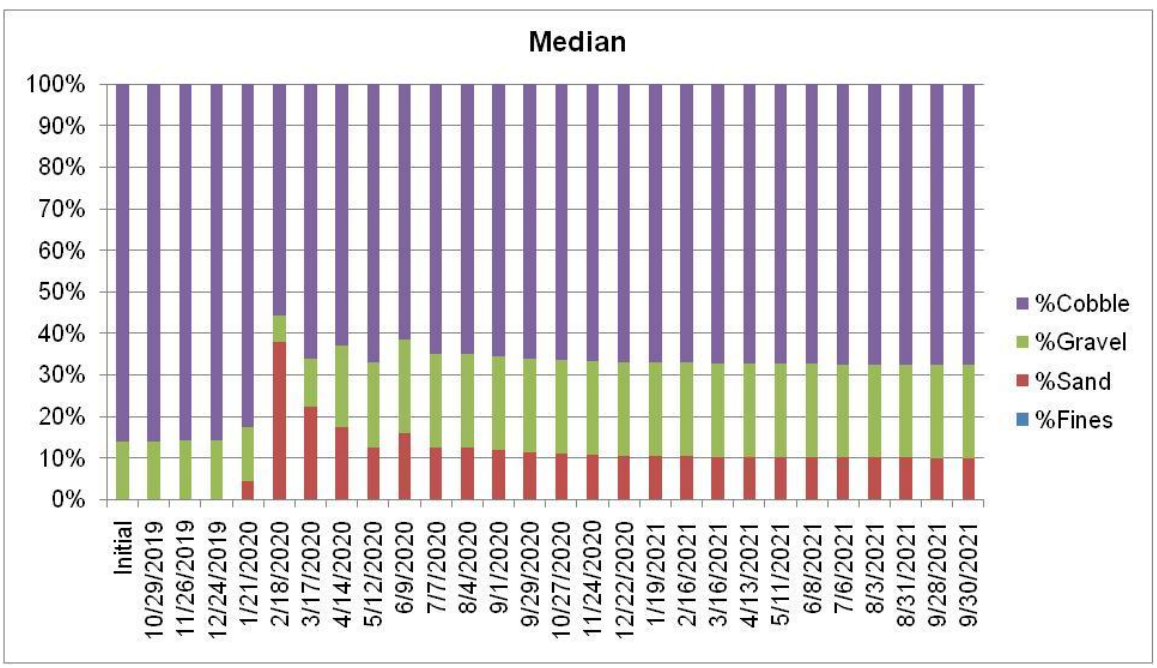


Figure F-7. Simulated Bed Composition from Iron Gate Reservoir to Copco 2 Dam during Two Successive Wet Water Years after Dam Removal



Source: Reclamation 2011.

Figure F-8. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Median Water Years after Dam Removal

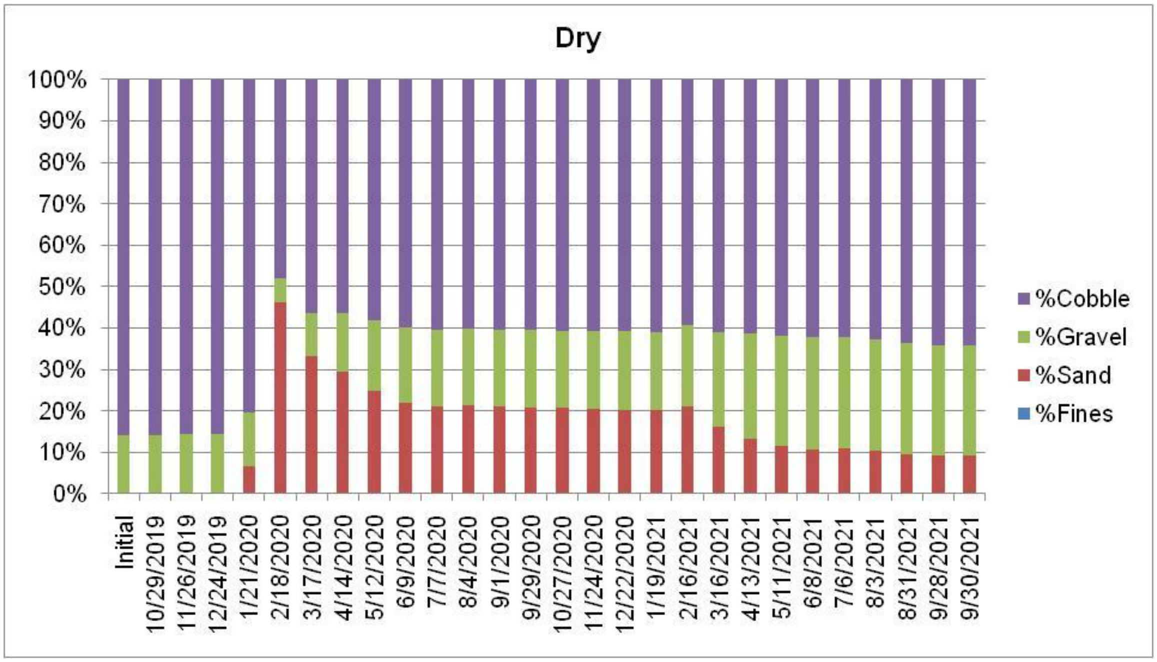


Figure F-9. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years after Dam Removal

Fall-Run Chinook Salmon

The Proposed Action Could Have Impacts on Pool Habitat

The Proposed Action could erode sediment from reservoirs within the Hydroelectric Reach and, at most, cause minor (less than 0.5 ft) deposition in river reaches between reservoirs (Figure F-2 and Figure F-3). River channels within reservoir reaches could excavate to their pre-dam elevations within four months, and likely revert to and maintain a pool-riffle morphology, similar to the Downstream of Iron Gate Dam reach, due to restoration of riverine processes along the Hydroelectric Reach (PacifiCorp 2004). This could create holding and rearing habitat for anadromous salmonids. The removal of the dams would also create access to these habitats and habitats in reaches upstream. Fall-run Chinook salmon would first access the Hydroelectric Reach in fall 2020, at which time, the removal of the dam structures to stream elevation is expected to be complete. **Effects to pool habitat for fall-run Chinook salmon in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

The Proposed Action Could Have Impacts on Spawning Habitat

The Proposed Action could increase median substrate sizes in the Hydroelectric Reach. SRH-1D results show that during fall of 2020, when fall-run Chinook salmon first return to spawn after dam removal, D50s would range from coarse gravel (16 to 32 mm) to small cobble (64 to 128 mm) (Figure F-4, Figure F-5, and Figure F-6), which is within the preferred range for Chinook salmon spawning (16 to 70 mm [Kondolf and Wolman 1993]). As discussed above, the proportion of sand in the bed may be still be as high as 40 percent in former reservoir reaches and in the reach from Iron Gate Reservoir to

Copco 2 Dam (Figure F-9, Attachment F-1, Figures F1-1 to F1-9), which may impact spawning success (Chapman 1988), but would still provide spawning opportunities. River reaches between reservoirs would provide the preferred substrate size range for fall-run Chinook salmon, with very little sand (Attachment F-1, Figures F1-10 to F1-15), suggesting high quality spawning habitat. The removal of the dams would also create access to these habitats and habitats in reaches upstream. **Effects to spawning habitat for fall-run Chinook salmon in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

Spring-Run Chinook Salmon

Spring-run Chinook salmon distribution extends from the mouth of the Klamath River upstream to the Salmon River (Stillwater Sciences 2010b). Most spawning and rearing takes place within the Trinity and Salmon rivers. The current distribution of spring-run Chinook salmon does not extend as far as the Hydroelectric Reach. If spring-run Chinook salmon expand their range in response to dam removal, then they would benefit from this action in the same manner as fall-run Chinook salmon. Because spring-run Chinook salmon generally do not spawn on the mainstem, this benefit would be less than that for fall-run Chinook salmon. **Effects to spring-run Chinook salmon in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

Coho Salmon

Most coho salmon spawn and rear in the tributaries, but the mainstem Klamath River does contain habitat suitable for all lifestages (Stillwater Sciences 2010c). Iron Gate Dam currently blocks the upstream migration of coho salmon to upper reaches (Hamilton et al. 2005). Before construction of the dams in the Hydroelectric Reach, coho salmon distribution extended at least as far upstream as Spencer Creek, which enters the mainstem in J.C. Boyle Reservoir (Hamilton et al. 2005). The Proposed Action would restore access to the mainstem Klamath River and its tributaries upstream of Iron Gate Dam, increasing available rearing and spawning habitat. The changes to pool and spawning habitat described above for fall-run Chinook salmon may also provide suitable conditions for coho salmon spawning. Coho generally do not spawn in the mainstem, so the benefits to this species would not be as great, in terms of mainstem spawning. However, some coho do rear in the mainstem, and access to the cooler waters associated with tributaries entering the Hydroelectric Reach would be expected to benefit salmonids rearing in the mainstem (Hamilton et al. 2010). Access would also be provided to upstream tributaries where spawning and rearing would be expected to occur. Coho salmon are expected to use all tributaries upstream as far as Spencer Creek, including Jenny, Spring, and Fall Creeks. **Effects to coho salmon in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

Summer Steelhead

Summer steelhead distribution extends from the mouth of the Klamath River upstream to Empire Creek (RM 166.8) and may be rare above Seiad Creek (RM 130.9) due to water high water temperatures (Stillwater Sciences 2010c). The current distribution of summer steelhead does not extend as far as the Hydroelectric Reach, which begins at RM 190.

Like coho salmon, summer steelhead are expected to spawn and rear primarily in tributary streams. The Proposed Action may result in cooler water temperatures downstream of Iron Gate Dam that may increase the length of usable salmonid spawning and rearing habitat (Hamilton et al. 2010). The increase in usable length may extend summer steelhead distribution upstream to the Hydroelectric Reach. If this occurs, benefits to habitat described for fall-run Chinook and coho salmon (above) would occur to summer steelhead as well. **Effects to summer steelhead in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

Winter Steelhead

Winter steelhead are distributed throughout the Klamath River up to Iron Gate Dam, but spawn and generally rear in the tributaries (FERC 2007). There is no record of winter steelhead spawning in the mainstem Klamath River, which is used mainly as a migration corridor for adults and juveniles (Stillwater Sciences 2010c). With the removal of the dams, winter steelhead would be able to re-establish themselves throughout their much of their historic range, including the mainstem and tributaries within the hydroelectric reach and the Upper Basin (Hamilton et al. 2005). **Effects to winter steelhead in the Hydroelectric Reach under the Proposed Action would be beneficial in the short- and long-term.**

Green Sturgeon

Green sturgeon distribution extends from the mouth of the Klamath River upstream to the Salmon River (RM 66.5), with some observed migrating into the Salmon River, but do not ascend past Ishi Pishi Falls (Moyle 2002, FERC 2007), nor are they expected to do so if the dams were removed. Most spawning and rearing takes place within the lower mainstems of the Klamath and Trinity rivers. **There would be no impact to green sturgeon in the Hydroelectric Reach under the Proposed Action.**

Redband Trout

Within the Hydroelectric Reach, redband trout migrate between tributaries and reservoirs to complete their lifecycle (Hamilton et al. 2010). The Proposed Action would eliminate reservoir habitat as dams within the Hydroelectric Reach are removed and sediment moves downstream (Figure F-2 and Figure F-3). **The impacts to redband trout reservoir habitat would be significant in the short- and long-term under the Proposed Action**.

The Proposed Action would also create riverine habitat in sections of river formerly inundated by reservoirs. **As such, the Proposed Action would be a long-term benefit to redband trout riverine habitat.**

Lost River and Shortnose Suckers

Federally endangered Lost River and shortnose suckers occur within the Hydroelectric Reach. The Proposed Action would eliminate reservoir habitat as dams within the Hydroelectric Reach are removed and sediment is allowed to move downstream (Figure F-2 and Figure F-3). However, there is little or no successful reproduction of either sucker species downstream of Keno Dam and contributes minimally to conservation goals or significantly to recovery (Hamilton et al. 2010). **Thus, although the Proposed**

Action would have negative long-term impact on Lost River and shortnose sucker habitat in the Hydroelectric Reach, the overall impact to the population would be less than significant.

Nonnative Reservoir Fish

As discussed above, the Proposed Action would eliminate reservoir habitat as dams are removed. **Eliminating this habitat would have a negative impact on habitat for nonnative reservoir fish.**

F.5.2 Lower Klamath River: Downstream of Iron Gate Dam

The streambed downstream of Iron Gate Dam would be affected by dam released sediment and reconnection of natural sediment supply from upstream. The sediment stored within dams has a high water content and 85 percent of the particles are silts and clays (less than 0.063 mm) while 15 percent are sand or coarser (greater than 0.063 mm) (GEC 2006, Stillwater Sciences 2008, Reclamation 2011). As such, most sediment eroded from the dams would be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (64 to 256 mm) (GEC 2006, Stillwater Sciences 2010c, Reclamation 2011) (Table F-2). Silt and finer substrate, which comprise a large proportion of the volume of stored sediments, would likely be transported as suspended sediment and would travel to the ocean shortly after being eroded and mobilized (GEC 2006). Coarser (greater than 0.063 mm) sediment would travel downstream more slowly, attenuated by channel storage and the frequency and magnitude of mobilization flows. The amount of sand transported in suspension would vary with discharge, with greater proportions of sand in suspension at higher discharges.

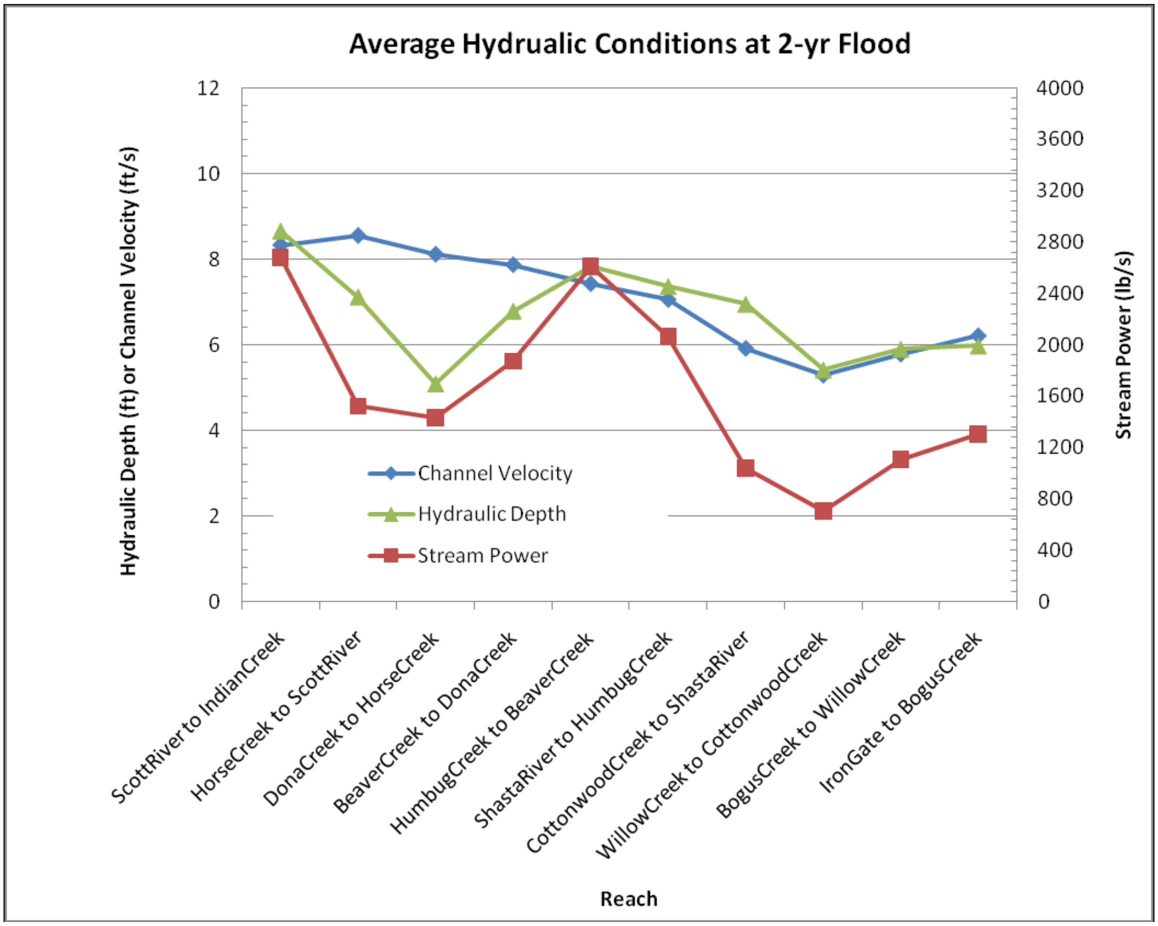
Table F-2. Estimated Mass (Tons) of Reservoir Released Sediment by Size Under Wet, Median and Dry Water Years

Substrate Size	Wet	Median	Dry
Silt (<0.063 mm)	2,352,233	1,808,719	1,238,525
Sand (0.063 to 2.0 mm)	185,797	276,558	124,371
Gravel (2 to 64 mm)	37,942	18,213	1,116
Cobble (64 to 256 mm)	5,889	1,513	76
Total	2,581,862	2,105,002	1,364,089

Source: Reclamation 2011

F.5.2.1 Downstream Extent of Effect

The effect of dam released sediment and sediment resupply likely extends from Iron Gate Dam to Cottonwood Creek (Reclamation 2011). Estimates of reach averaged stream power (based upon channel depth, width, and slope)) show a decrease from Iron Gate Dam to Cottonwood Creek, with stream power then increasing again downstream of Cottonwood Creek (Figure F-10). The increase suggests that short- or long-term sediment deposition, either from dam release or sediment resupply, is unlikely downstream of Cottonwood Creek. Using Cottonwood Creek as the downstream extent of bedload related effects, 8 miles of channel could potential be affected by sediment release and resupply. The affected channel represents 4 percent of the total channel length of the mainstem Klamath River downstream of Iron Gate Dam (190 miles).



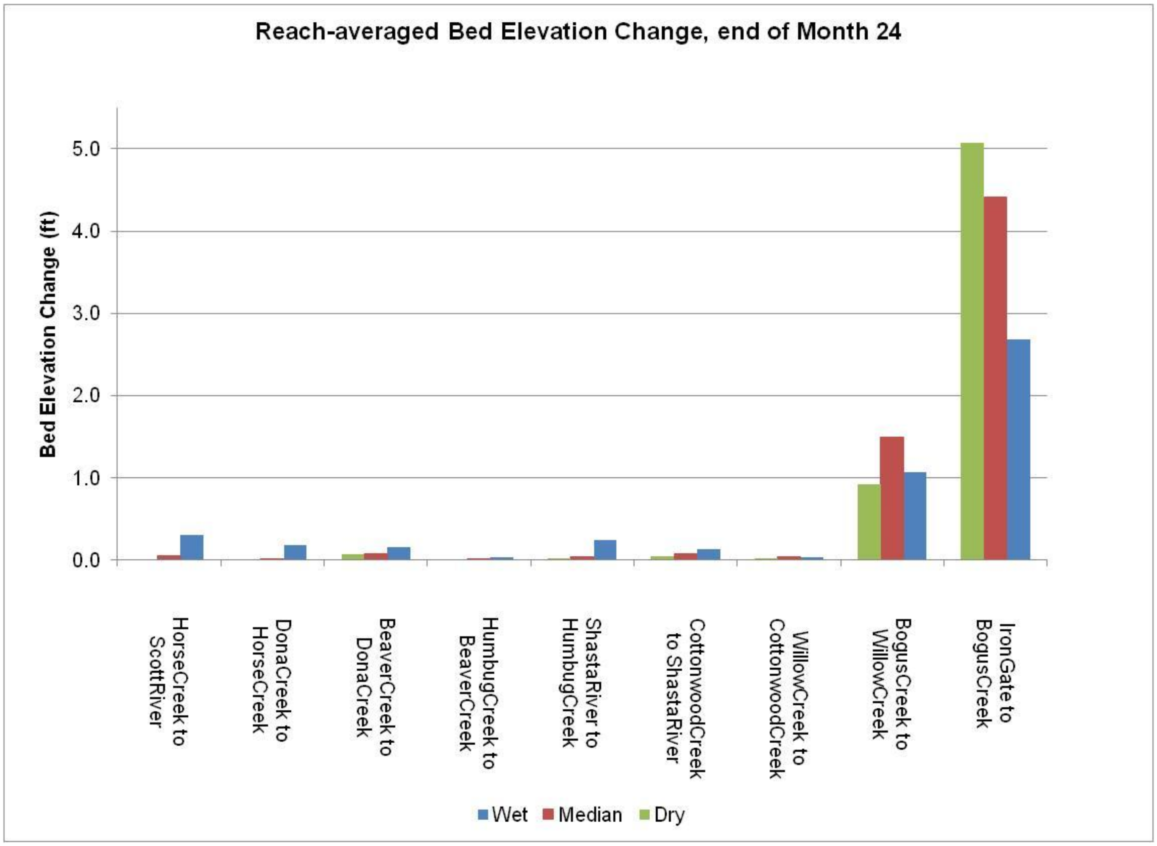
Source: Reclamation 2011.

Figure F-10. Reach Averaged Stream Power Downstream of Iron Gate Dam

F.5.2.2 Changes in Bed Elevation

Short-term (2-yr) SRH-1D model simulations estimate up to 5 ft of reach averaged deposition between Iron Gate Dam and Bogus Creek (RM 189.8) (2.5 to 5 ft), decreasing downstream between Bogus Creek and Willow Creek (RM 185.2) (1.0 to 1.5 ft), reaches farther downstream showed no apparent increase (Figure F-11). Reach averaged bed elevation between Iron Gate Dam to Bogus Creek would increase by 5 ft after drawdown (January 2020) until March 2020 under dry and median simulations, and would increase by 3 ft after drawdown until April 2020 under the wet simulation (Figure F-12). Elevations under the dry and median simulation would approach a level similar to the wet simulation (3 feet) over time as flows carry dam released sediment downstream. The reach from Bogus Creek to Willow Creek would experience lesser increases in average bed elevation, but with similar short-term temporal patterns (Figure F-13).

In the long-term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium, which includes sediment supplied by upstream tributaries that was formerly trapped by dams within the Hydroelectric Reach. Reclamation (2011) expects 2 to 3 feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years.



Source: Reclamation 2011.

Figure F-11. Reach Averaged Bed Elevation after Two Successive Wet, Median, or Dry Water Years

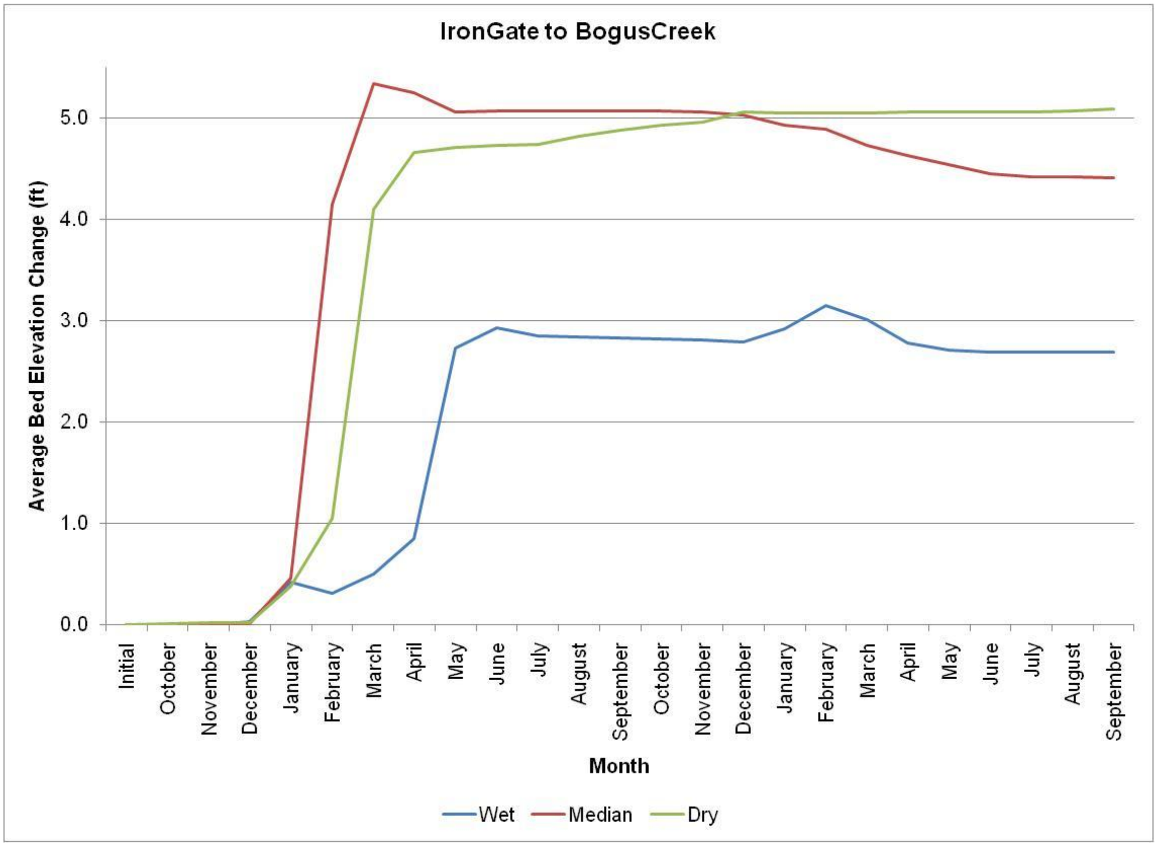


Figure F-12. Reach Averaged Bed Elevation during Two Successive Wet, Median, or Dry Water Years from Iron Gate Dam to Bogus Creek

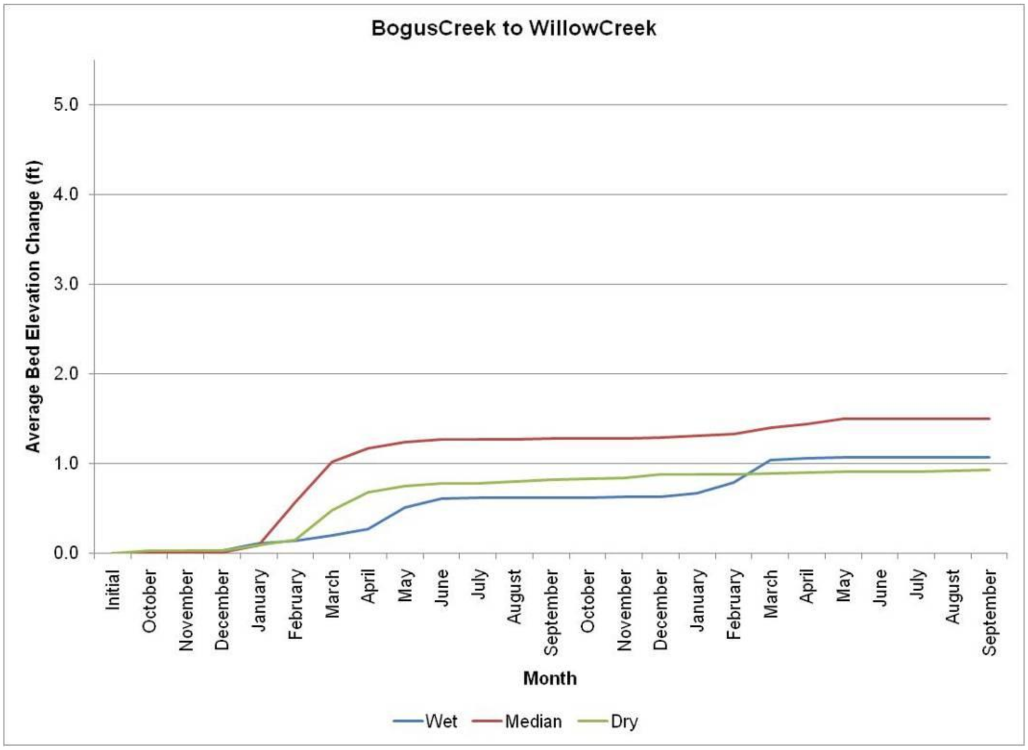
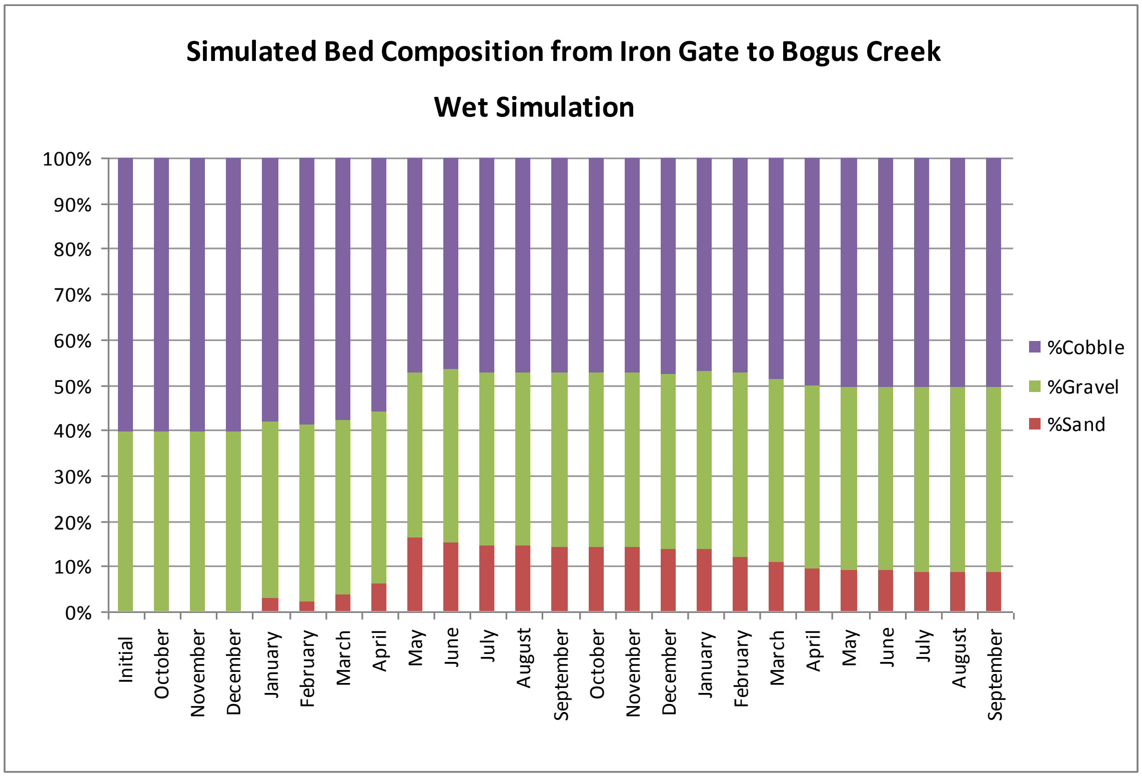


Figure F-13. Changes in Each Averaged Bed Elevation 50 Years after Dam Removal

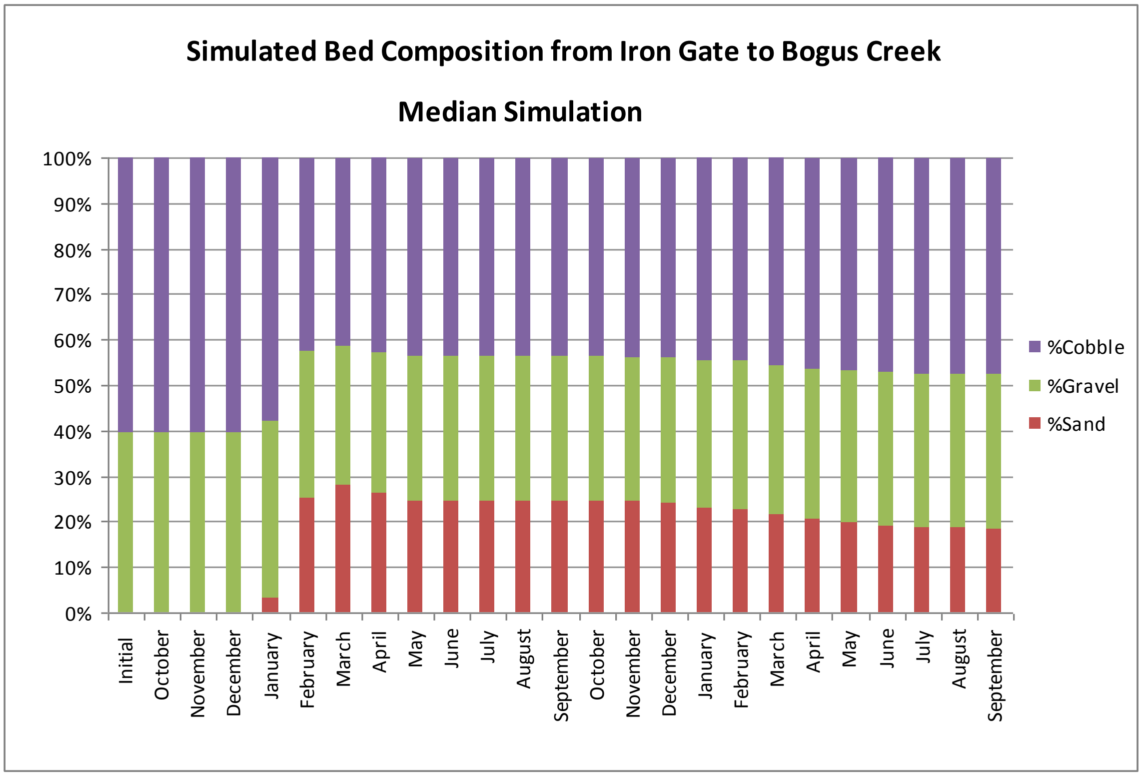
F.5.2.3 Changes in Bed Substrate

In the short-term (less than 2 years), SRH-1D model output indicates dam released sediment and sediment resupply would increase the proportion of sand in the bed and decrease median bed substrate size (Reclamation 2011). The model assumes that the channel bed is initially sand free with a D50 of 75 mm, representing current conditions where the bed is sediment starved due to upstream trapping of coarse sediment by dams. Under wet and median simulations, sand within the bed would increase to 15 to 30 percent by March 2020 after drawdown, gradually decreasing to 10 to 20 percent by September 2021, while median substrate size would decrease to 50 to 60 mm then gradually increase to 60 to 65 mm (Figure F-14, Figure F-15, and Figure F-16). The model predicts that after two successive dry years, the proportion of sand on the bed would increase to 30 percent and median substrate size would decrease to 45 mm after drawdown in January 2020 to March 2020 and remain at these values though to September 2021 (Figure F-16 and Figure F-17). The reach from Bogus Creek to Willow Creek showed a slight increase in the proportion of sand (less than 10 percent under all simulations) and a minimal decrease in median substrate size (Attachment F-1 Figures F1-16 to F1-19). Willow Creek to Cottonwood Creek showed no short-term changes in sand composition or median substrate sizes (Attachment F-1, Figures F1-20 to F1-23). The probability of flushing dam released fine sediment from the Iron Gate Dam to Bogus Creek reach depends upon flow. Reclamation (2011) estimated a flow of 7,500 cfs would flush dam released sand and smaller substrate from the reach. The probability of this flow occurring during the drawdown year was 15 percent, increasing to 54 percent by the third year, and 67 percent by the fifth year.



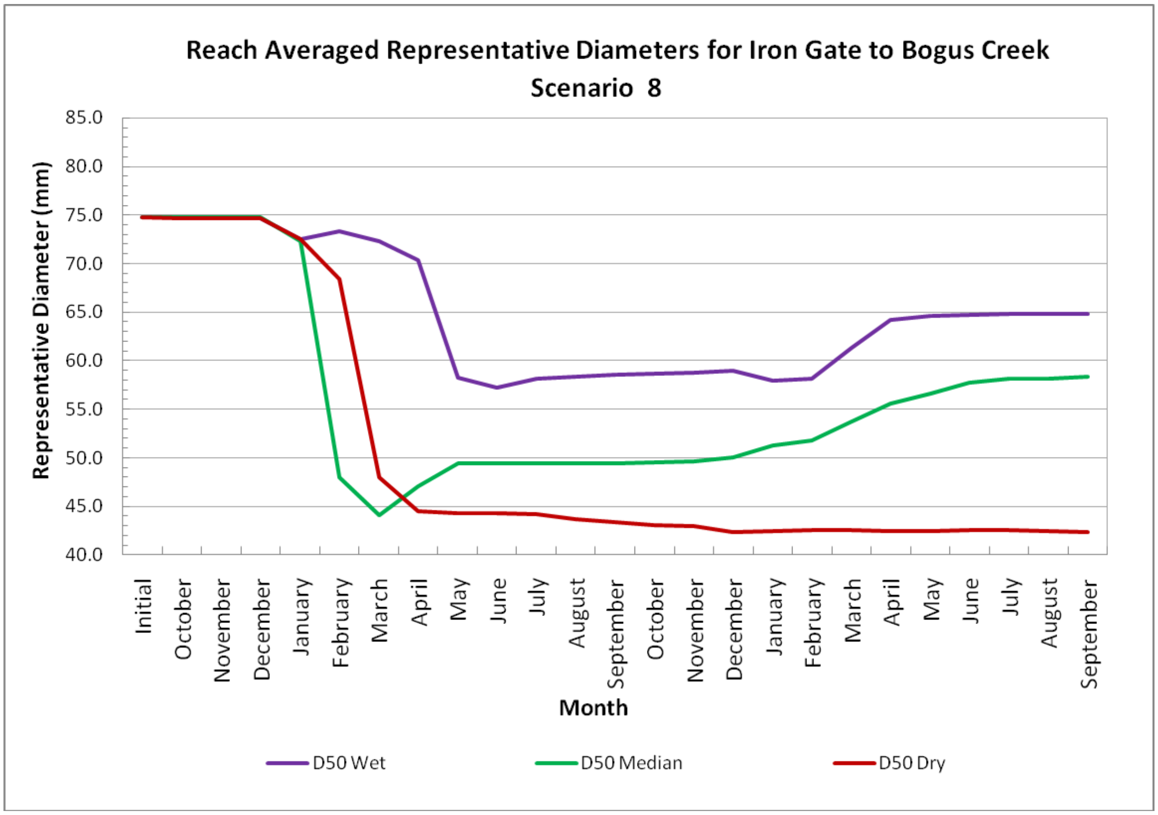
Source: Reclamation 2011.

Figure F-14. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Wet Water Years Dam Removal



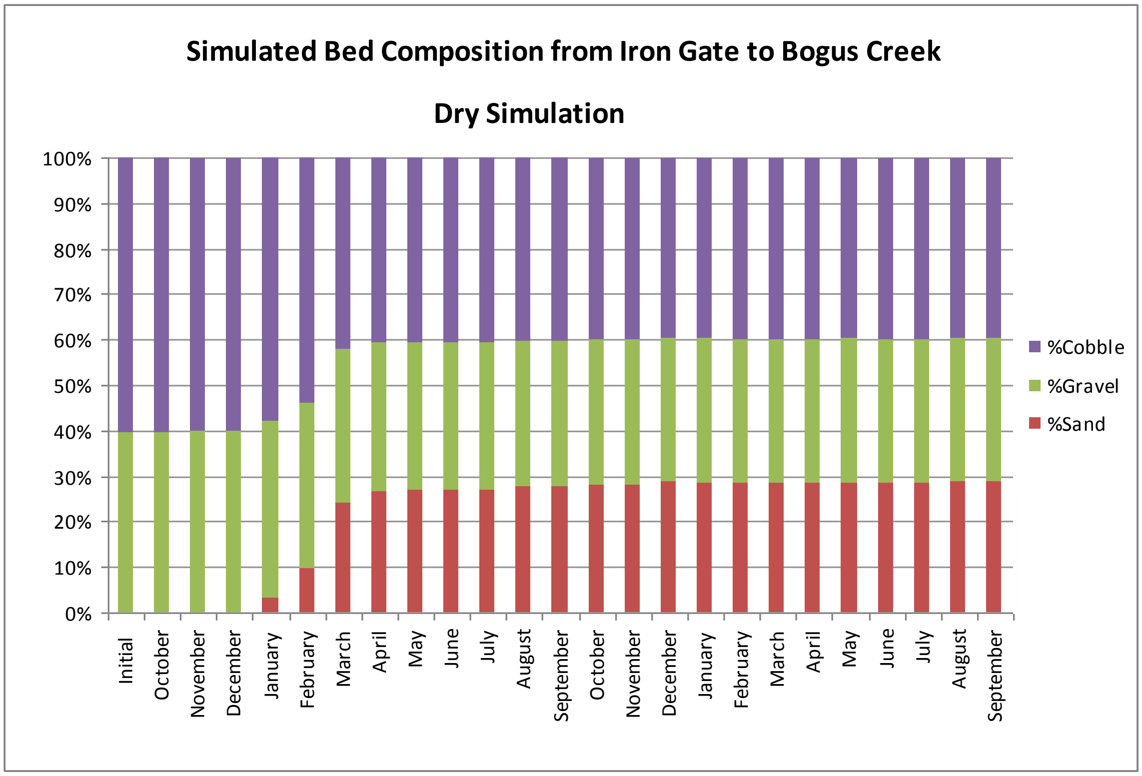
Source: Reclamation 2011.

Figure F-15. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Wet Water Years Dam Removal



Source: Reclamation 2011.

Figure F-16. Simulated D50 (mm) From Iron Gate Dam to Bogus Creek During Successive Wet, Median, and Dry Water Years



Source: Reclamation 2011.

Figure F-17. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Dam Removal

Longer-term (5, 10, 25, and 50 years) simulations show increases in the proportion of sand to 5 to 22 percent and decreases in D50 to approximately 50 to 55 mm (Attachment F-1, Figures F1-24 to F1-30) after five years that stabilize and continue through to year 50. Reaches downstream of Cottonwood Creek showed no long-term changes to bed composition or substrate size (Reclamation 2011).

Under the Proposed Action, the flows required to mobilize bed sediment would decrease as the bed would become finer due to dam released sediment and sediment resupply from upstream tributaries. Reclamation (2011) estimated the magnitude and return period of flows required to mobilize sediment downstream of Iron Gate Dam 50 years after dam removal using reach averaged predicted grain sizes from long-term SRH-1D simulations. The estimates show that under the Proposed Action, sediment mobilization flows from Bogus Creek to Willow Creek and from Willow Creek to Cottonwood Creek would range from 3,000 to 7,000 cfs (1.5 to 2.5 year return period) and 5,000 to 9,000 cfs (1.5 to 3.2 year return period), respectively, lower than current conditions or the No Action/No Project Alternative. Downstream of the Shasta River, there would be no difference in bed mobilization flows or return period between the Proposed Action and current conditions or the No Action/No Project Alternative.

Impact Statements

Fall-run Chinook Salmon

The Proposed Action Could Have Short-Term Impacts On Spawning Habitat

As discussed above effects on bed substrate are limited to the 8-mile reach from Iron Gate Dam to Cottonwood Creek (4 percent of current total channel length). The most pronounced effects occur in the 0.5-mile reach from Iron Gate Dam to Bogus Creek, where SRH-1D modeling results estimate that from February to April 2020, when fall-run Chinook salmon fry spawned in 2019 would emerge, the proportion of sand in the bed may be as high as 20 to 30 percent under the dry scenario (Figure F-17). This amount of sand could negatively impact embryo survival to emergence (Chapman 1988). During the fall of 2020 under the dry scenario, SRH-1D results also show that when fall-run Chinook salmon first return to spawn after dam removal, median substrate size may be as low as 40 mm (Figure F-16). This falls within the observed range for Chinook salmon spawning (16 to 70 mm [Kondolf and Wolman 1993]), but the high sand composition could impact spawning success.

The high sand content would be limited to a small proportion of the total channel length (less than 1 percent [0.5 mi]), as sediment deposition lessens downstream of Bogus Creek to Cottonwood Creek (Figure F-11). Further, the effects would only occur in successive median or dry years (Figure F-15 and Figure F-17), the proportion of sand in the substrate in successive wet years could be 10 to 15 percent (Figure F-14). If dry or median years occurs in the first two years, there is a 54 percent probability that flows could transport dam released sand and finer substrate from the reach within 3 years, and a 67 percent probability after 5 years (Reclamation 2011). Flume experiments conducted by Stillwater Sciences (2008) also found that the amount of fine sediment infiltrating into the channel bed during sediment pulses decreased with depth below the surface, with significant deposition only observed to a shallow depth. The results suggest that fine sediment infiltration into the gravel bed (and potential spawning gravel) during dam removal would be minimal and short-lived, able to be transported downstream during subsequent high flows.

Short-term (2–yr) aggradation of sediment from the dams could be substantial below Iron Gate Dam downstream to Willow Creek, with up to 5 feet of deposition within 0.5 miles downstream of the dam, to 1.5 feet of deposition near Willow Creek (Figure F-12 and Figure F-13). The amount of deposition within these reaches is expected to bury any salmonid redds and associated eggs to such a depth that alevin emergence would likely be adversely affected. Farther downstream, depositional depths are such that alevins in the gravel would likely not be affected.

Adult fall-run Chinook salmon returning to spawn the Iron Gate Dam to Bogus Creek reach in 2020, and potentially in 2021 would encounter a higher proportion of sand in the substrate than what was present prior to dam removal. The proportion of sand in the bed is projected to be 10 to 30 percent (Figure F-14, Figure F-15, Figure F-17). Salmonids are naturally adapted to select spawning habitat that maximizes egg survival and do so in response to geomorphic processes alter river channels from year to year. Adults returning in 2020 or 2021 would still spawn in the Iron Gate Dam to Bogus Creek reach if suitable habitat was present. If no suitable habitat exists, adults could choose to spawn in downstream reaches or newly accessible (due to dam removal) upstream reaches with suitable habitat. Because of this behavioral adaptation, eggs of fall-run Chinook salmon returning in 2020 or 2021 would likely be unaffected by the changes described above.

Fall-run Chinook salmon eggs deposited in the fall of 2019 in the reach from Iron Gate Dam to Bogus Creek could be lost; and less substantial losses may continue to occur downstream to the vicinity of Willow Creek. Nonetheless, only a small proportion (4 percent) of basin-wide fall-run Chinook spawning occurs in the mainstem Klamath River (FERC 2007). Additionally, the changes described above affect a small proportion of the total habitat available to the species on the mainstem below Iron Gate Dam (8 miles or 4 percent of current total channel length, Figure F-10) and do not affect tributaries that may provide additional habitat. Finally, these effects are likely to occur in only a single year. **Based on this, potential changes to spawning habitat would likely not have a significant short-term impact to fall-run Chinook salmon.**

The Proposed Action Could Have Long-Term Impacts on Spawning Habitat
Five years after dam removal, SRH-1D estimates that the proportion of sand in the bed would be less than 15 percent and median substrate sizes would be near 55 mm in all reaches from Iron Gate Dam to Cottonwood Creek (Attachment F-1, Figures F1-24 to F1-30) (Reclamation 2011). Less than 15 percent sand in spawning gravel is not expected to substantially reduce survival to emergence and 55 mm falls within the observed range for Chinook salmon spawning (16 to 70 mm [Kondolf and Wolman 1993]). Flows occurring after the pulse of dam released sediment has passed downstream are expected to reduce bed elevations from those that occur immediately following dam removal (Figure F-12), but the bed elevation would be expected to remain higher than pre-dam removal conditions (Reclamation 2011). Additional bed aggradation may occur as sediment supplied from tributaries to the Hydroelectric Reach is transported to and deposited within reaches downstream of the dams. These changes are not expected to negatively affect fall-run Chinook salmon spawning. These changes would stabilize and remain consistent through 50 years and are **not anticipated to impact fall-run Chinook salmon spawning habitat.**

The Proposed Action Could Have Short-Term Impacts on Pool Habitat
The Proposed Action could increase the level of sediment deposition downstream of Iron Gate dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the current total channel length. The deposition may aggrade pools or overwhelm other habitat features used for adult holding or juvenile rearing. The most pronounced effects occur in the 0.5 mile reach from Iron Gate Dam to Bogus Creek where SRH-1D modeling results show that sediment deposition might increase bed elevation by as much as 3 to 5 ft within the first two years (Figure F-11 and Figure F-12), depending on water year type. This may affect the depth and area of available pool habitat. The SRH-1D model estimates reach average changes and is not capable of providing data on a morphologic unit-scale (e.g., pool), or describing how sediment is distributed along the channel (Stillwater Sciences 2008, Reclamation 2011). Flume experiments conducted by Stillwater Sciences (2008) found that a coarse-bedded channel with pool-riffle morphology, similar to that

found in the Klamath River below Iron Gate Dam, would maintain pool topography during temporary channel filling (i.e., during pulses of fine and coarse sediment). Pools are erosional features, evacuating sediment pulses before other morphologic units (e.g., riffles), and would likely return to their pre-sediment release depth after downstream translation of the pulse (Stillwater Sciences 2008). These results suggest that effects on pool habitat would likely be minor. The most severe effects would also be limited to a small proportion of the total channel length (less than1 percent [0.5 mi]), as sediment deposition lessens downstream of Bogus Creek to Cottonwood Creek (Figure F-11). The lifestages of fall-run Chinook salmon that use pools, adults, juveniles, and fry are not tied to specific pools and are capable of seeking desirable areas. **Based on this, potential changes to pool habitat would likely not have a significant short-term impact to fall-run Chinook salmon.**

The Proposed Action Could Have Long-Term Impacts on Pool Habitat
In the long-term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium that includes sediment supplied by upstream tributaries (sediment that was formerly trapped by dams within the Hydroelectric Reach). Reclamation (2011) expects 2 to 3 feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years. The river would likely revert to and maintain its natural pool-riffle morphology, similar to current condition, and pool frequency, size, and depth would likely remain similar. **Impacts would be less than significant.**

Spring-Run Chinook Salmon
Spring-run Chinook salmon distribution extends from the mouth of the Klamath River upstream to the Salmon River (Stillwater Sciences 2010b). Most spawning and rearing takes place within the Trinity and Salmon rivers. As discussed in above, bedload sediment effects related to dam released sediment or sediment resupply likely extend as far as the Cottonwood Creek, with the most pronounced effect occurring between Iron Gate Dam and Bogus Creek, and thus would not affect the area currently used by spring-run Chinook salmon. **There would be no impact to spring-run Chinook salmon in the Lower Klamath River Reach under the Proposed Action.**

Coho Salmon
The Proposed Action Could Have Short-Term Impacts on Spawning Habitat
Recent estimates show that 100 adults or fewer spawned within the mainstem Klamath River along the 63 mile reach from Iron Gate Dam to Portuguese Creek from 2001–2004 (Hamilton et al., 2010). Most coho salmon spawn in tributaries to the Klamath River. Most rearing occurs on these tributaries as well, although some coho juveniles may rear in the mainstem when conditions in the tributaries become unsuitable. **The effects of bedload and sediment composition changes would likely eradicate any coho salmon eggs that were spawned on the mainstem above Willow Creek in 2019, although the number is expected to be very low because most spawning occurs in tributaries. In subsequent years, coho salmon would be able to behaviorally adapt to bed**

composition changes (i.e., disperse to suitable spawning habitat), and no effect would be expected.

The Proposed Action Could Have Long-Term Impacts on Spawning Habitat
Five years after dam removal, SRH-1D estimates that the proportion of sand in the bed would be less than15 percent and median substrate sizes would be near 55 mm in all reaches from Iron Gate Dam to Cottonwood Creek (Attachment F-1, Figures F1-24 to F1-30) (Reclamation 2011). The median substrate size may limit coho spawning in the mainstem Klamath River, as the observed range for coho salmon spawning is 5 to 35 mm (Kondolf and Wolman 1993). However, most coho spawn in tributaries with very few observed spawning in the mainstem (Hamilton et al. 2010, Stillwater Sciences 2010c). It is also likely that areas of suitably sized gravel would occur on the mainstem, although their distribution would likely be limited. Less than 15 percent sand in spawning gravel is not expected to substantially reduce survival to emergence (Chapman 1988). **These effects are not anticipated to impact coho salmon spawning habitat.**

The Proposed Action Could Have Short-Term Impacts on Pool Habitat
The impacts to coho salmon resulting from short-term filling of pools in the mainstem would be negligible for the same reasons described for fall-run Chinook salmon. **Impacts would be less than significant.**

The Proposed Action Could Have Long-Term Impacts on Pool Habitat
The impacts to coho salmon resulting from long-term filling of pools in the mainstem would be negligible for the same reasons described for fall-run Chinook salmon. **Impacts would be less than significant.**

Summer Steelhead
Summer steelhead currently occupy the Klamath River downstream of Empire Creek (RM 166.8). This run of steelhead spawns in tributaries, although some fish may rear in the mainstem. **The short-term bedload sediment impacts associated with dam removal are not expected to intersect with their current distribution, and therefore would not impact this species.**

Winter Steelhead
Winter steelhead adults and juvenile use the mainstem Klamath River mainly as a migration corridor (Stillwater Sciences 2010b), but access the river all the way to Iron Gate Dam. A small proportion of the population may rear in some areas where coolwater refugia are present. Like summer steelhead, spawning occurs in tributaries (Stillwater Sciences 2010c). **Changes in bedload and geomorphology would not impact spawning or incubation habitat and would have minimal effect on rearing habitat as described for fall-run Chinook salmon and summer steelhead.**

Green Sturgeon
As discussed above, bedload sediment effects related to dam released sediment or sediment resupply likely extend as far as the Cottonwood Creek. Current green sturgeon distribution extends from the mouth of the Klamath River upstream to the Ishi Pishi Falls

(Moyle 2002, FERC 2007), with some observed migrating into the Salmon River. **As there is no overlap between these two areas, there would be no impact to green sturgeon in the Lower Klamath River Reach under the Proposed Action.**

F.5.3 Klamath River Estuary

As discussed in above, bedload sediment effects related to dam released sediment or sediment resupply likely do not extend as past Cottonwood Creek. **Therefore, there would be no bedload related impacts to aquatic species in the Klamath River Estuary Reach under the Proposed Action.**

F.5.4 Pacific Ocean Near Shore Environment

As discussed above, bedload sediment effects related to dam released sediment or sediment resupply likely do not extend as far downstream as Cottonwood Creek (RM 180). **There would be no bedload related impacts to aquatic species in the Pacific Ocean near shore environment under the Proposed Action.**

F.6 Partial Facilities Removal of Four Dams Alternative

Alternative 3-Partial Facilities Removal would remove enough of each dam to allow free-flowing river conditions and volitional fish passage at all times. Under the partial removal alternative, portions of each dam would remain in place along with ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes, all of which would be outside of the 100-year flood prone width. Under this alternative, embankment/earth-filled dam and concrete dam structures would be removed (see Chapter 5) similar to the Proposed Action, allowing release of dam-stored sediment. Effects and impacts to bedload sediment under the Partial Facilities Removal Alternative are expected to be the same as those for the Proposed Action: Full Facilities Removal.

F.7 Fish Passage at Four Dams Alternative

Under Alternative 4, Fish Passage at Four Dam, fish passage structures would be installed at each dam to allow for upstream fish passage (see Chapter 5). No portion of the dams would be removed under this alternative and sediment would continue to be stored behind project dams, similar to the No Action/No Project Alternative. Effects and impacts to bedload sediment under the Partial Facilities Removal Alternative are expected to be the same as under the No Action/No Project Alternative.

F.8 Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Under this alternative, J.C. Boyle Dam would continue to store sediment, but the storage capacity of Copco 2 Dam would likely be filled by the release of sediments during the Copco 1 Dam. This scenario has not been modeled, but the effects of bedload sediment movement under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative are expected to be similar to, but of slightly lesser magnitude, than under Alternative 2 Proposed Action: Full Facilities Removal.

F.9 Mitigation Measure Analysis: Proposed Action with Mechanical Sediment Removal

The Mechanical Sediment Removal (dredging) mitigation measure would remove sediment from J.C. Boyle, Copco 1, and Iron Gate Reservoirs prior to and during dredging. Dredging would occur where the sediment would be most easily eroded during drawdown of the reservoirs according to the following assumptions:

- Historical river channel would be eroded to its pre-dam elevation
- Historical tributaries would be eroded to their pre-dam course and elevation
- Narrow and steep canyons would erode
- The reservoir side slopes erode at a slope of 10 Horizontal: 1 Vertical

The volume of sediment removed under the Mechanical Sediment Removal mitigation measure is shown in Table F-3.

Table F-3. Estimated Volume (yd^3) and Mass (Tons) of Sediment Currently Stored within Hydroelectric Reach Reservoirs

Reservoir	Sediment Volume (yd^3) Dredged Pre-Drawdown	Sediment Volume (yd^3) Dredged During Drawdown	Sediment Volume (yd^3) Dredged Total
J.C. Boyle	335,900	219,500	555,400
Copco 1	176,600	1,277,500	1,454,100
Copco 2	0	0	0
Iron Gate	106,100	733,100	839,200
Total	618,600	2,230,100	2,848,700

Source: Reclamation 2011

The Mechanical Sediment Removal mitigation measure would reduce the amount of sediment released downstream compared to the Proposed Action. Most sediment eroded from the dams would still be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (64 to 256 mm), but 35-40 percent less overall mass would be released downstream than under the Proposed Action (Table F-4). The discussion below focuses on the reach from Iron Gate Dam to Bogus Creek, which had the greatest changes in bed elevation and bed substrate composition (compared to downstream reaches) under the Proposed Action.

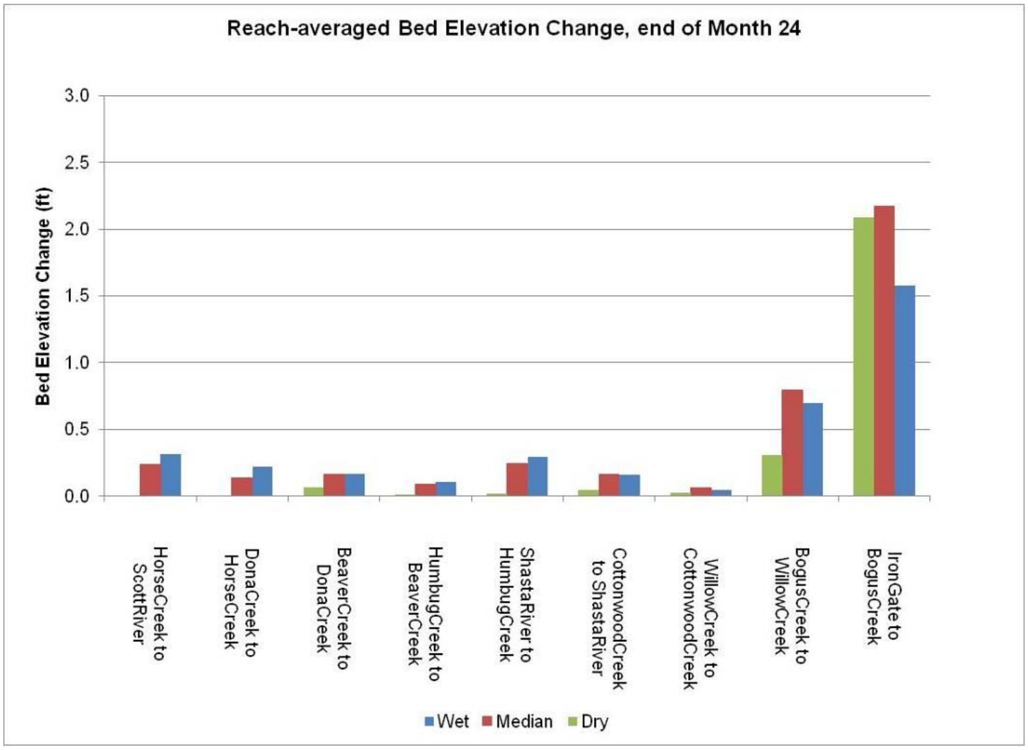
Table F-4. Estimated Mass (Tons) of Reservoir Released Sediment by Size Under Wet, Median and Dry Water Years

Substrate Size	Wet	Median	Dry
Silt (<0.063 mm)	1,617,174	1,213,062	783,952
Sand (0.063 to 2.0 mm)	117,119	134,544	39,718
Gravel (2 to 64 mm)	8,841	7,074	15
Cobble (64 to 256 mm)	1,196	518	3
Total	1,744,331	1,355,199	823,688

Source: Reclamation 2011

F.9.1 Changes in Bed Elevation

Under the Mechanical Sediment Removal mitigation measure, short-term (2-yr) SRH-1D model simulations estimate up to 2 ft of reach averaged deposition between Iron Gate Dam and Bogus Creek (compared to nearly 5 feet under the Proposed Action), decreasing downstream to 0.5 foot between Bogus Creek and Willow Creek (compared to > 1 foot under the Proposed Action) (Figure F-18 and Figure F-11). Reach averaged bed elevation between Iron Gate Dam to Bogus Creek would show the same temporal patterns as under the Proposed Action, with increases after drawdown (January 2020) until March 2020 (Figure F-19 and Figure F-12).



Source: Reclamation 2011.

Figure F-18. Reach Averaged Bed Elevation after Two Successive Wet, Median, or Dry Water Years with Dredging

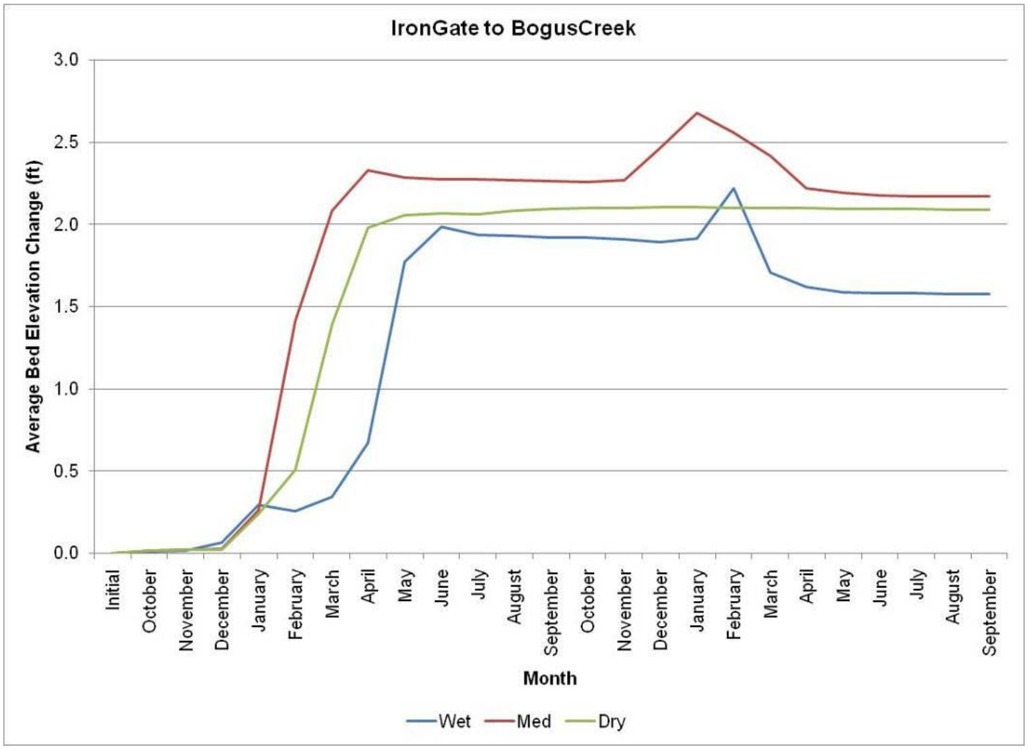
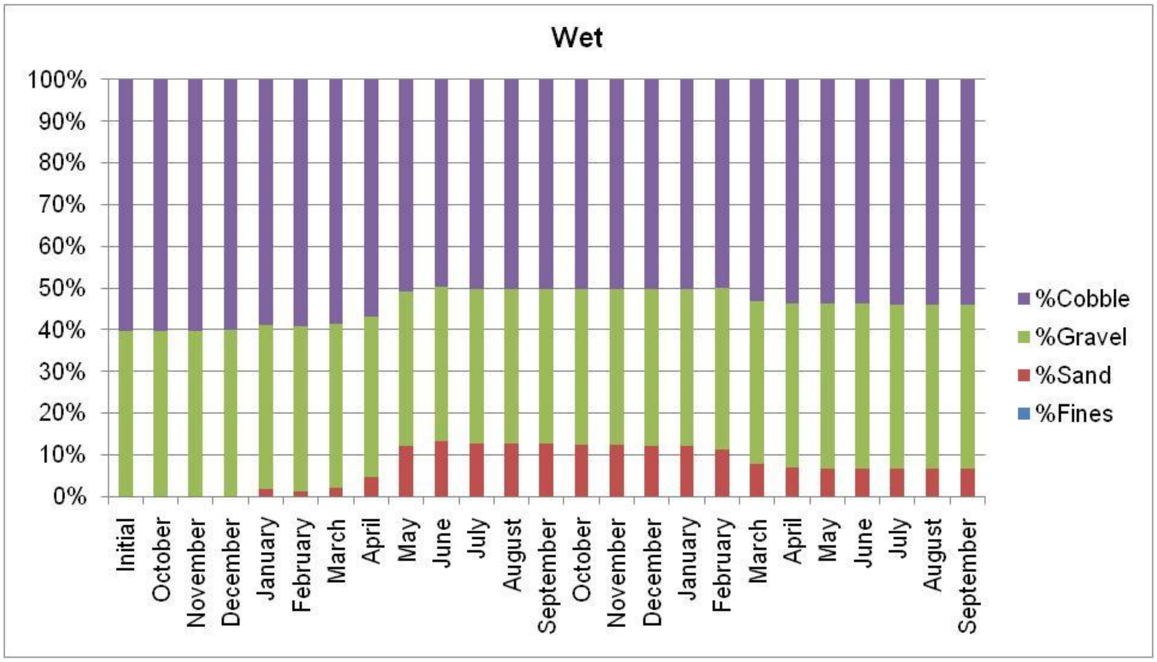


Figure F-19. Reach Averaged Bed Elevation with Dredging during Two Successive Wet, Median, or Dry Water Years from Iron Gate Dam to Bogus Creek

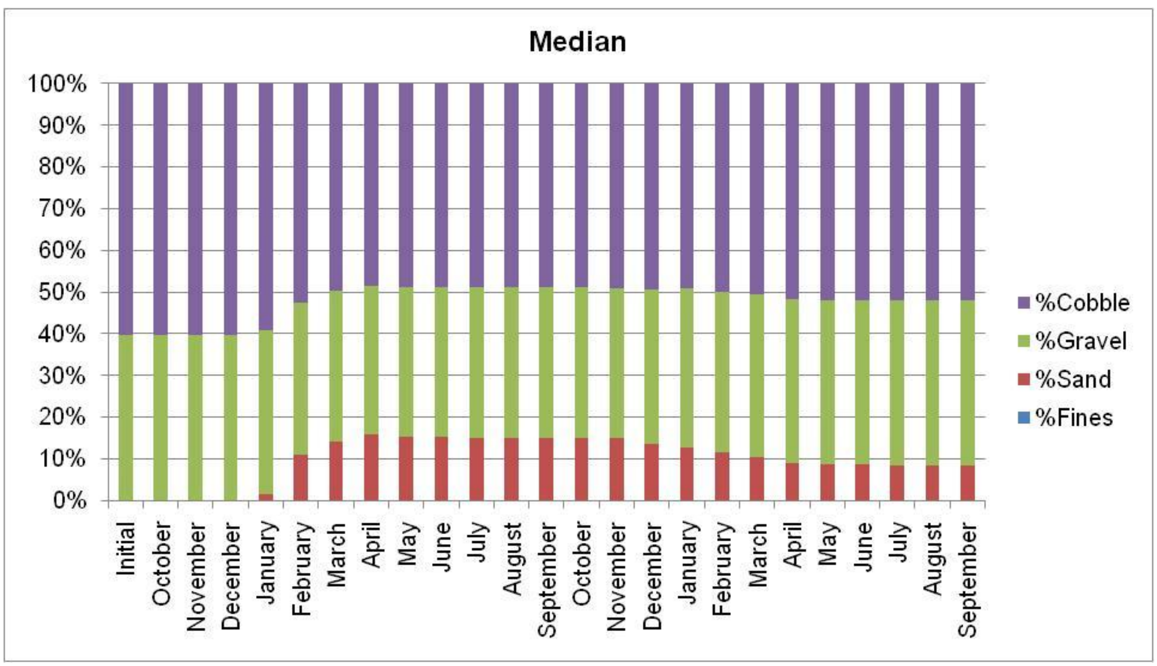
F.9.2 Changes in Bed Substrate

Mechanical Sediment Removal would still result in increases in the proportion of sand in the bed and decreases median bed substrate size, although the changes would be less than under the Proposed Action. SRH-1D estimated that sand within the bed from Iron Gate Dam to Bogus Creek would increase to 10 to 15 percent by March 2020 after drawdown, gradually decreasing to more than 10 percent by March 2021 under wet and median simulations, but remain near 15 percent through 2021 under the dry simulation (Figure F-20, Figure F-21 and Figure F-22). Median substrate size would decrease to 60 mm and gradually increase to 65 mm under wet and median simulations, but remain near 60 mm under the dry simulation (Figure F-23). Reclamation (2011) also predicted that most, if not all, sand and smaller substrate would be flushed from the reach within 3 years.



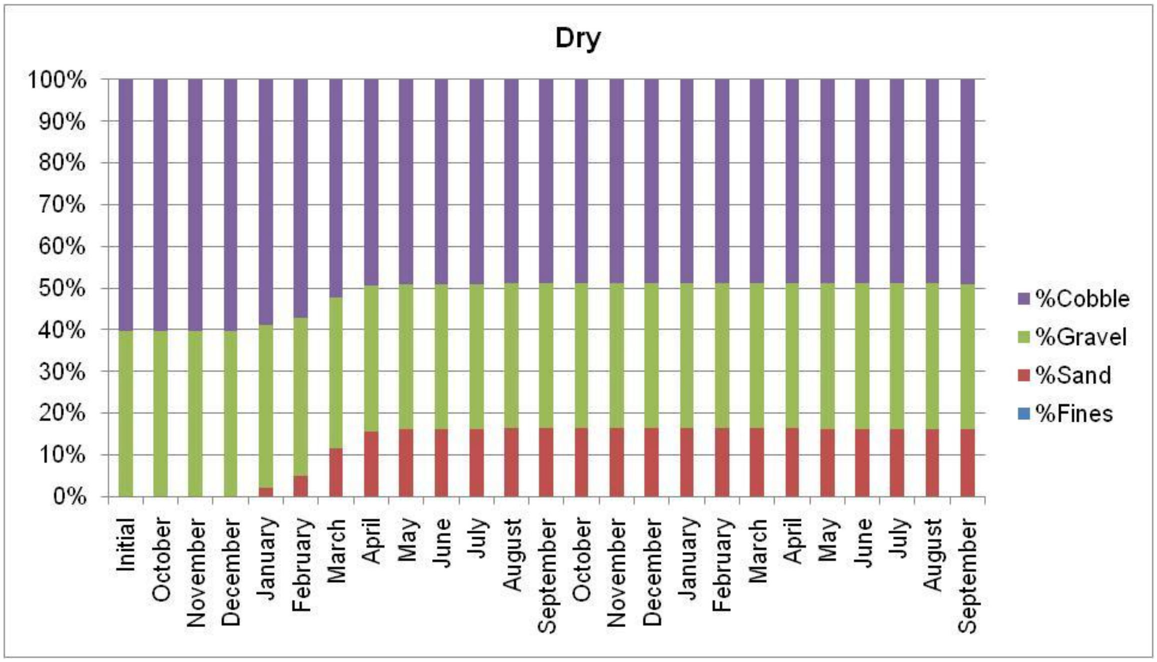
Source: Reclamation 2011.

Figure F-20. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Wet Water Years Dam Removal with Dredging



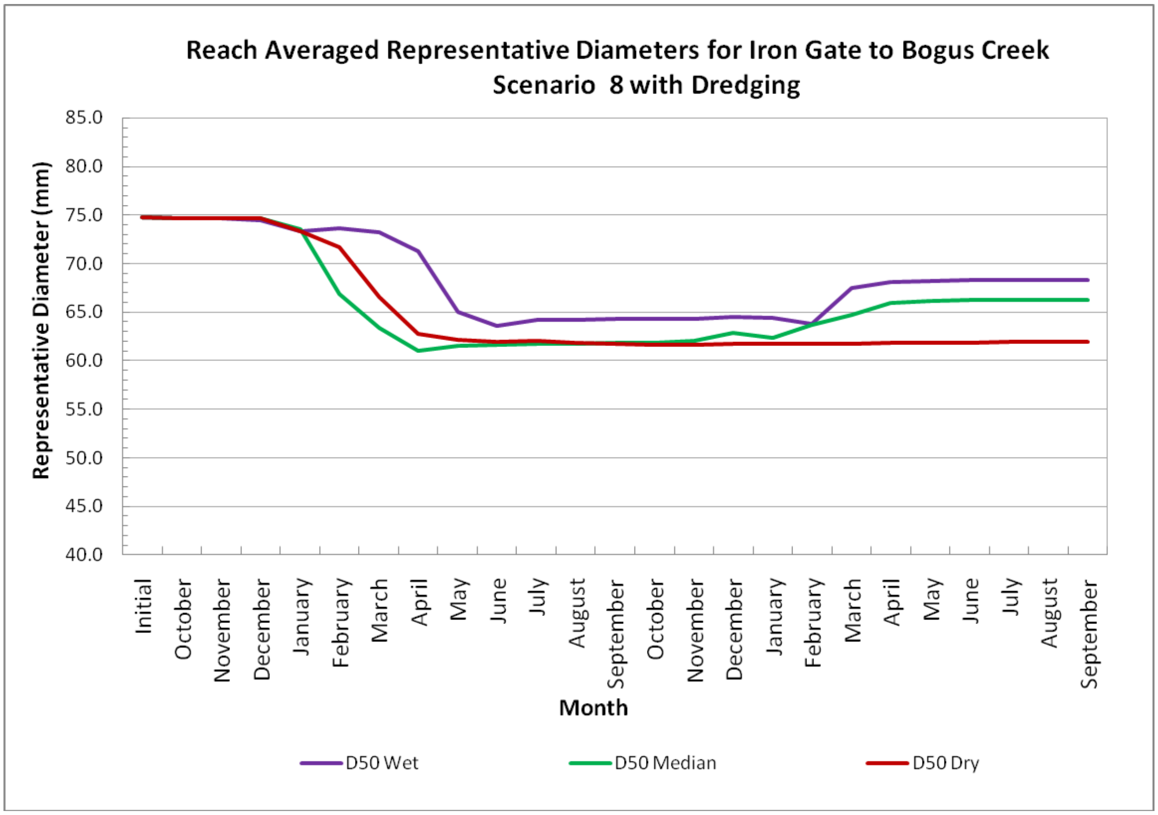
Source: Reclamation 2011.

Figure F-21. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Wet Water Years Dam Removal with Dredging



Source: Reclamation 2011.

Figure F-22. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Dam Removal with Dredging



Source: Reclamation 2011.

Figure F-23. Simulated D50 (mm) From Iron Gate Dam to Bogus Creek During Successive Wet, Median, and Dry Water Years with Dredging

Overall, the Mechanical Sediment Removal mitigation measure, relative to the Proposed Action, would result in less deposition downstream of Iron Gate Dam, and less sand within the bed and greater median substrate sizes in downstream reaches. These changes would lessen the severity of effects associated with dam released sediment and would also lessen severity of impacts to native fish in the mainstem Klamath River.

F.10 References

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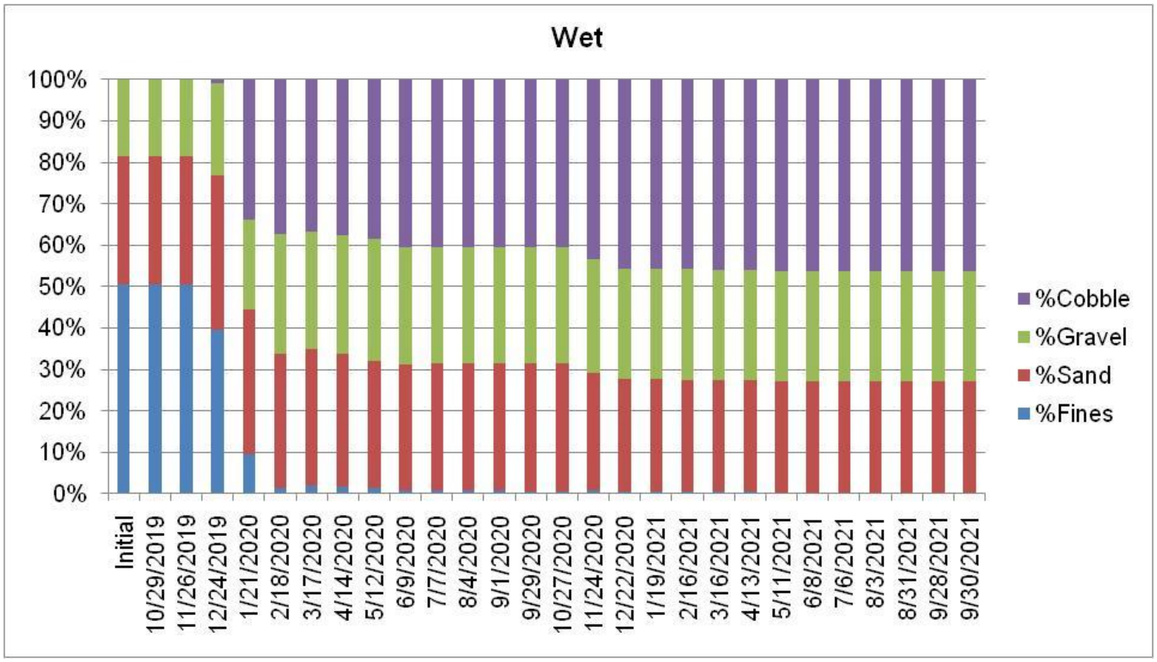
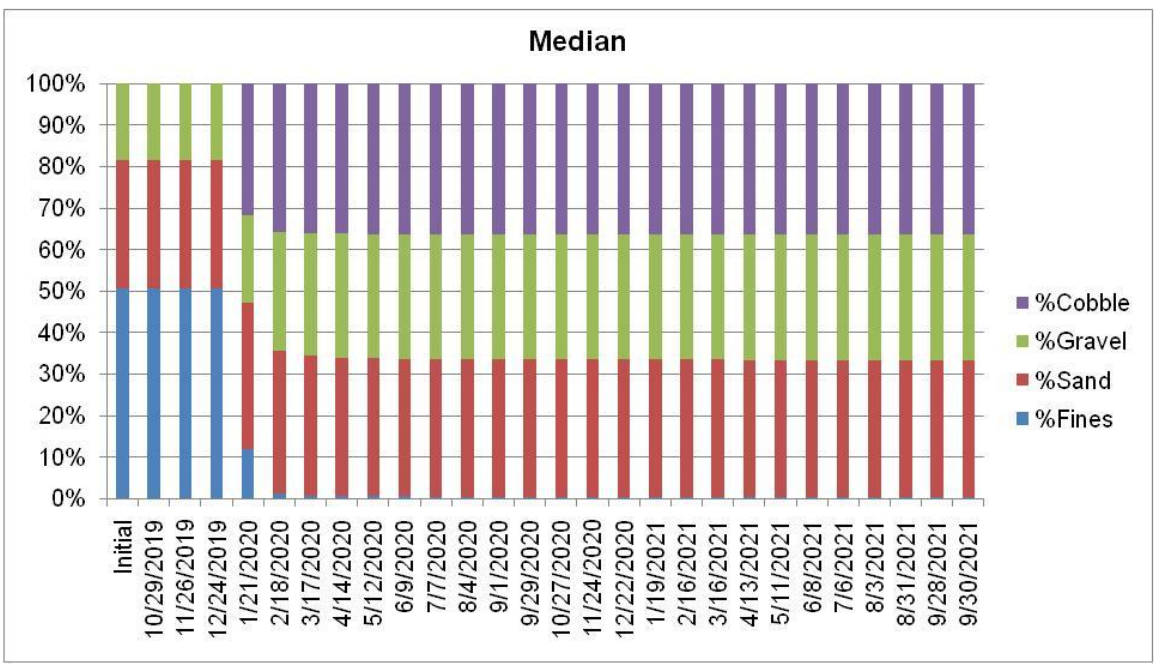
Varyu, D. Pers. comm., January 4, 2011.

Attachment F-1
Bedload Sediment Effects in the Hydroelectric Reach in the Lower Klamath Basin: Downstream of Iron Gate Dam to Cottonwood Creek



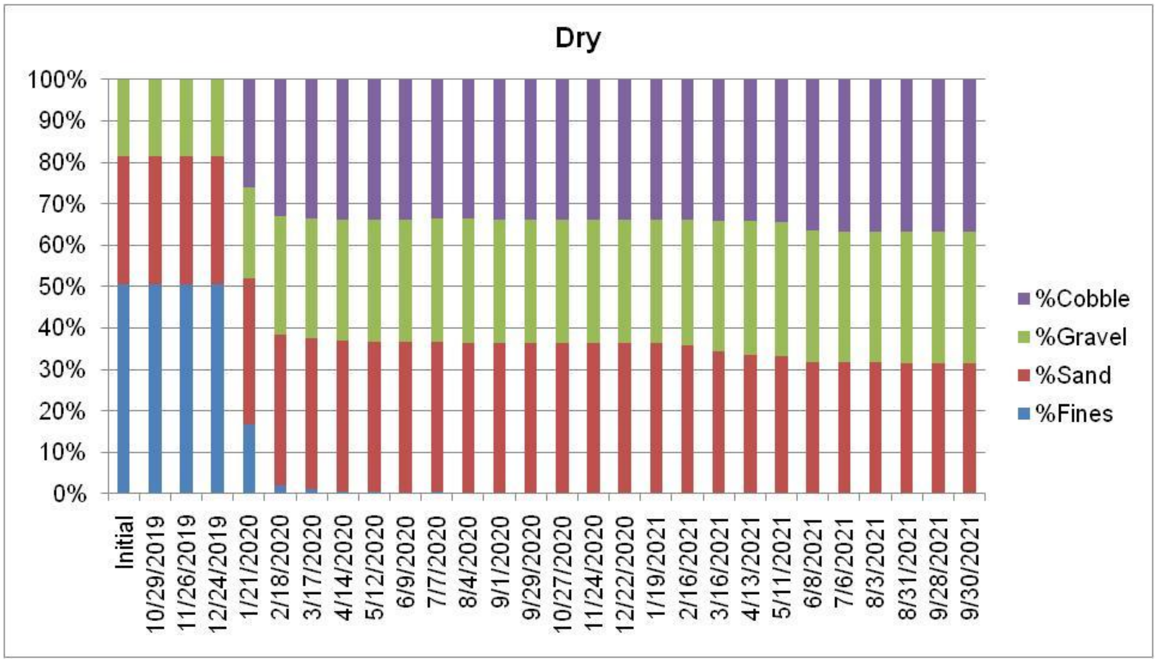
Source: Reclamation 2011.

Figure F1-1. Simulated Bed Composition for J.C. Boyle Reservoir during Two Successive Wet Water Years after Dam Removal



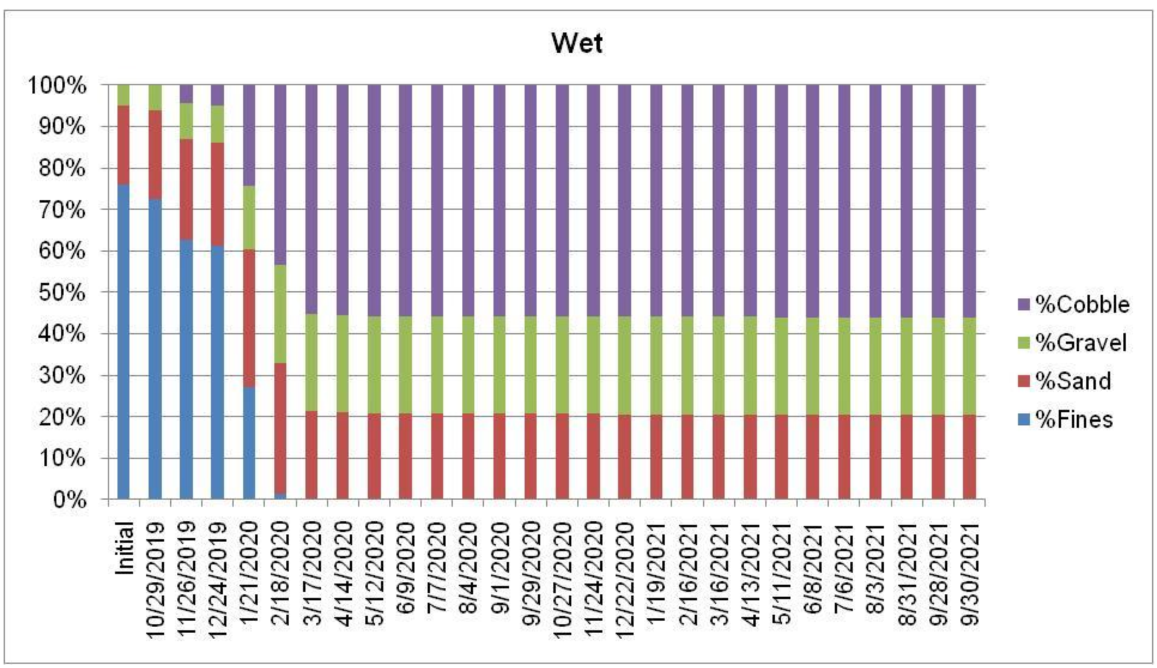
Source: Reclamation 2011.

Figure F1-2. Simulated Bed Composition for J.C. Boyle Reservoir during Two Successive Median Water Years after Dam Removal



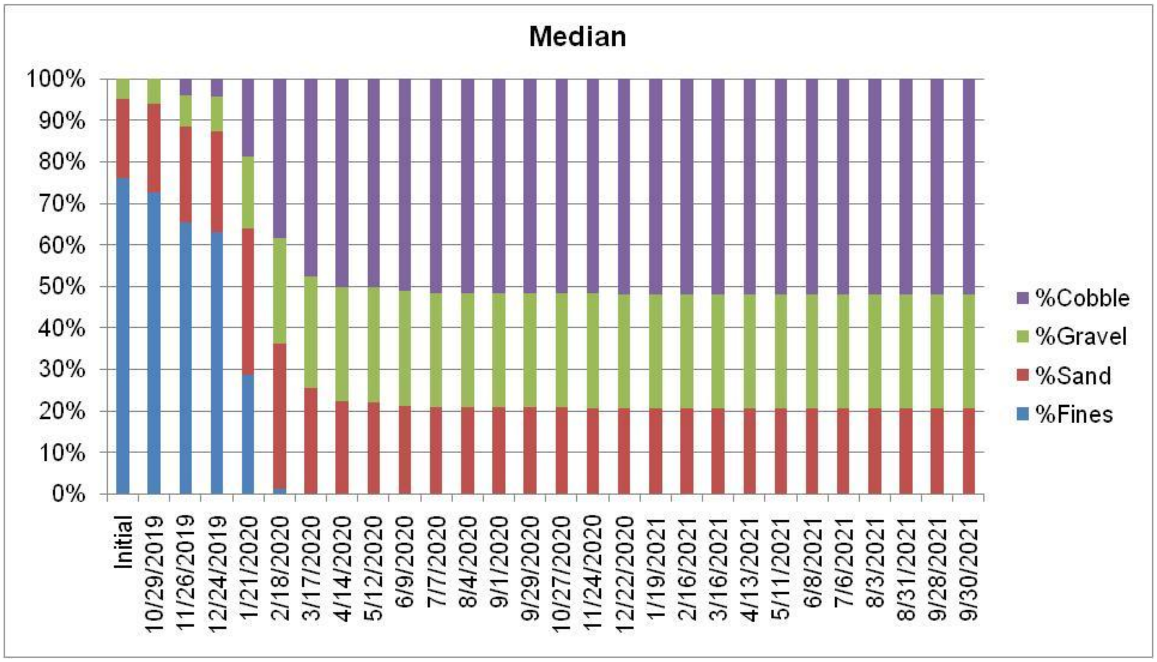
Source: Reclamation 2011.

Figure F1-3. Simulated Bed Composition for J.C. Boyle Reservoir during Two Successive Dry Water Years after Dam Removal



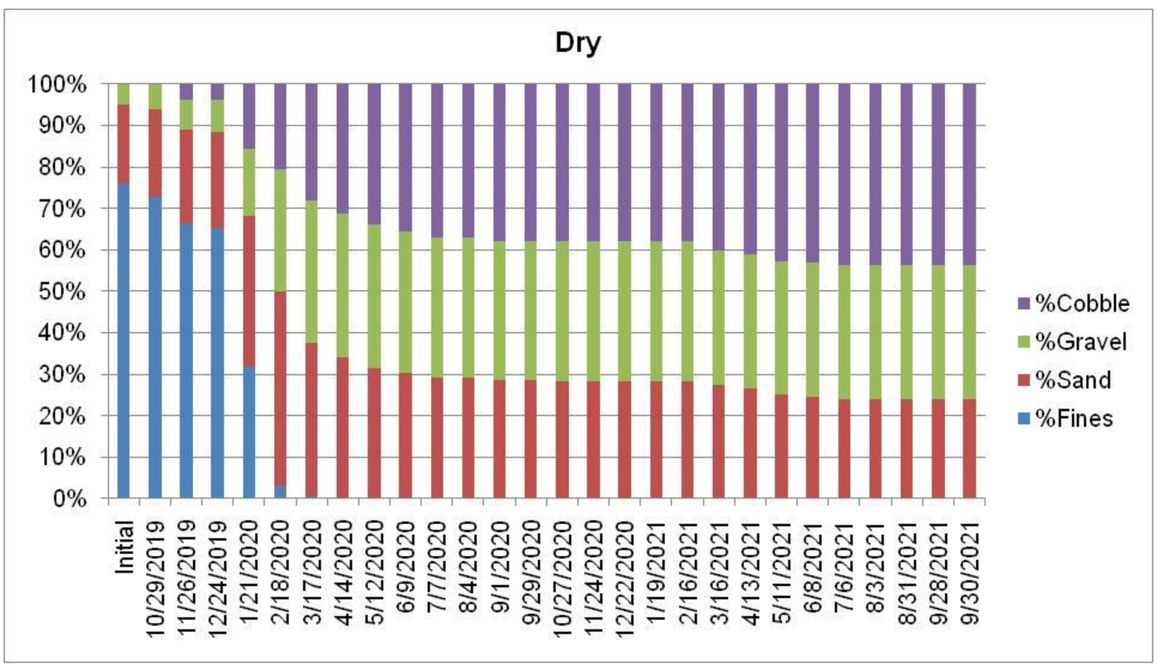
Source: Reclamation 2011.

Figure F1-4. Simulated Bed Composition for Copco 1 Reservoir during Two Successive Wet Water Years after Dam Removal



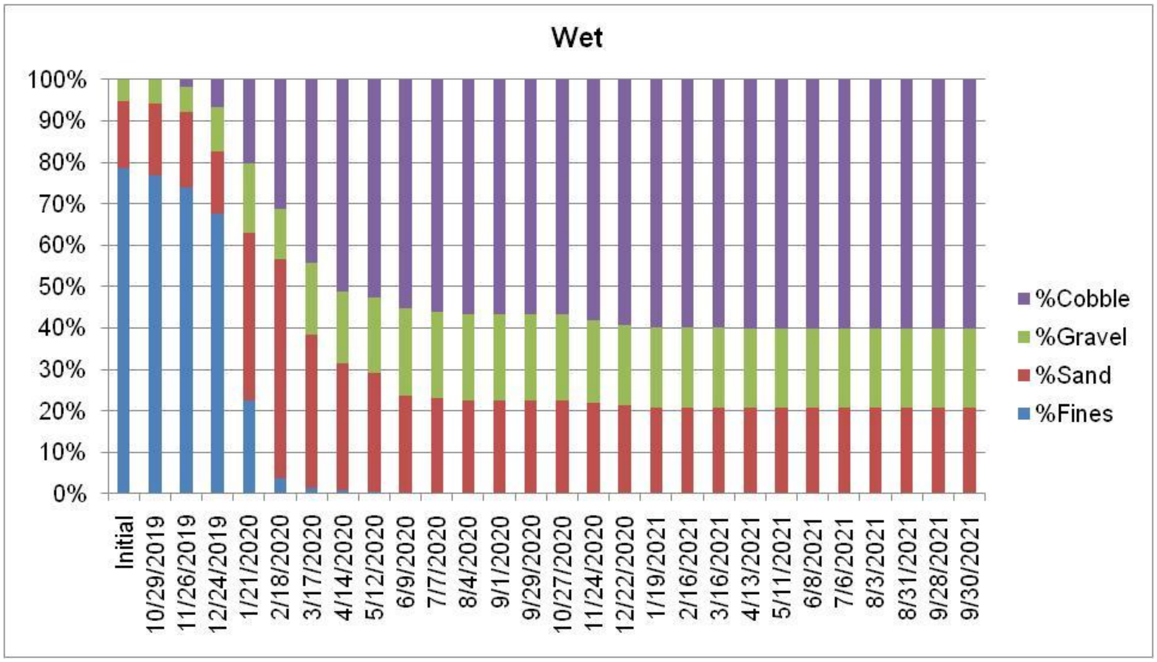
Source: Reclamation 2011.

Figure F1-5. Simulated Bed Composition for Copco 1 Reservoir during Two Successive Median Water Years after Dam Removal



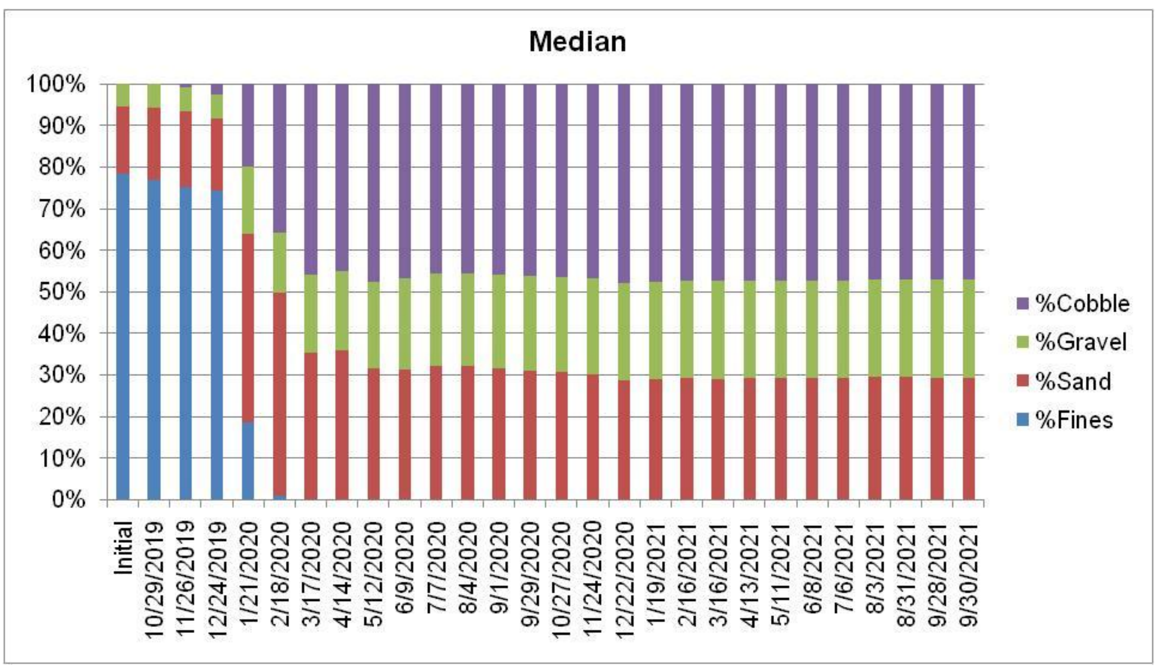
Source: Reclamation 2011.

Figure F1-6. Simulated Bed Composition for Copco 1 Reservoir during Two Successive Dry Water Years after Dam Removal



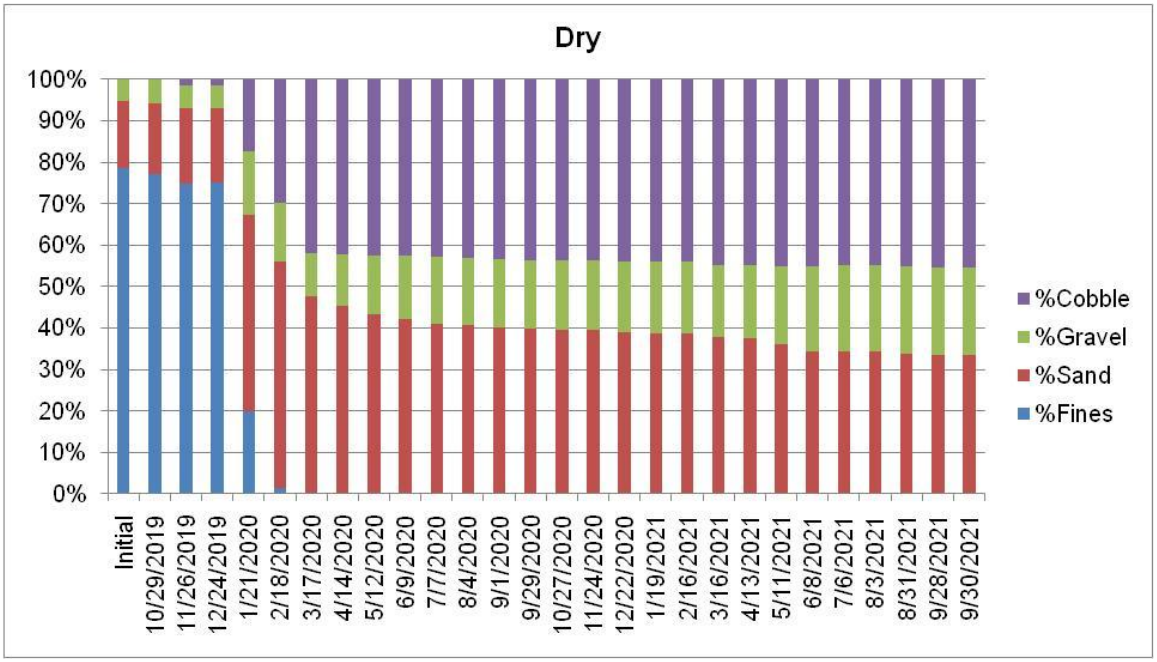
Source: Reclamation 2011.

Figure F1-7. Simulated Bed Composition for Iron Gate Reservoir during Two Successive Wet Water Years after Dam Removal



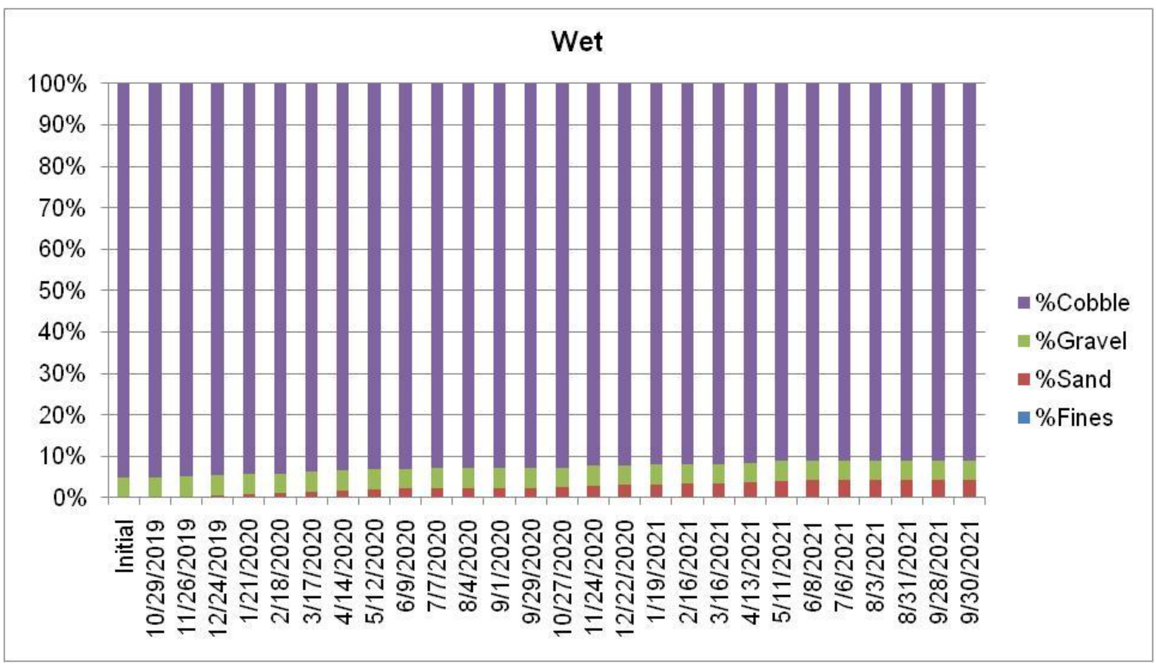
Source: Reclamation 2011.

Figure F1-8. Simulated Bed Composition for Iron Gate Reservoir during Two Successive Median Water Years after Dam Removal



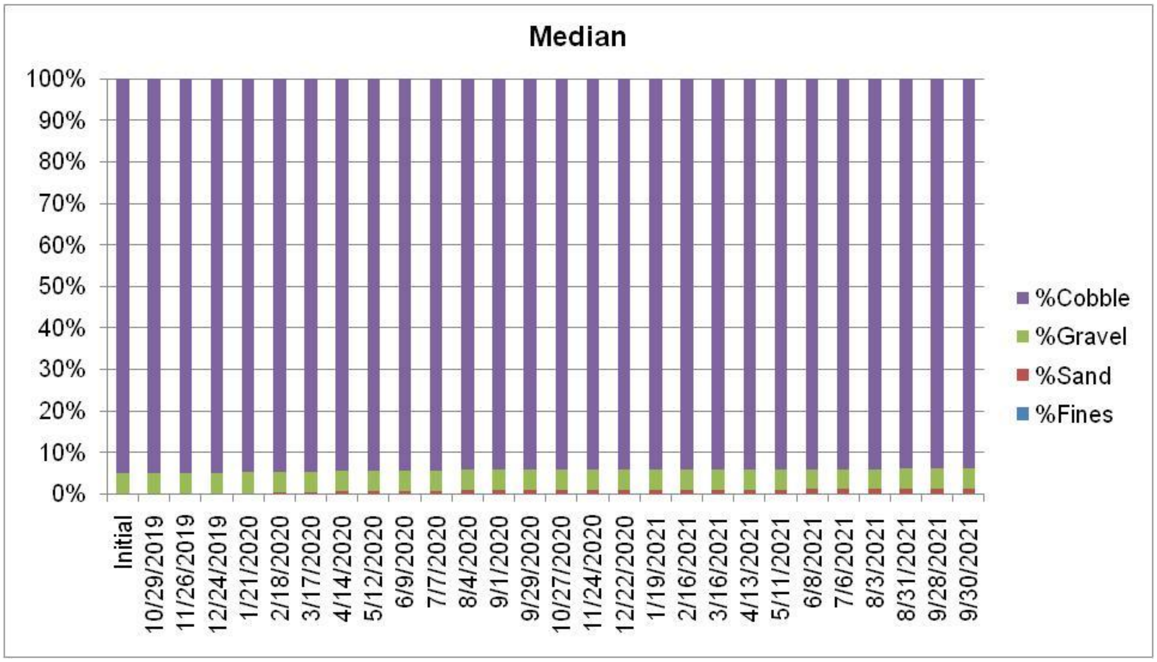
Source: Reclamation 2011.

Figure F1-9. Simulated Bed Composition for Iron Gate Reservoir during Two Successive Dry Water Years after Dam Removal



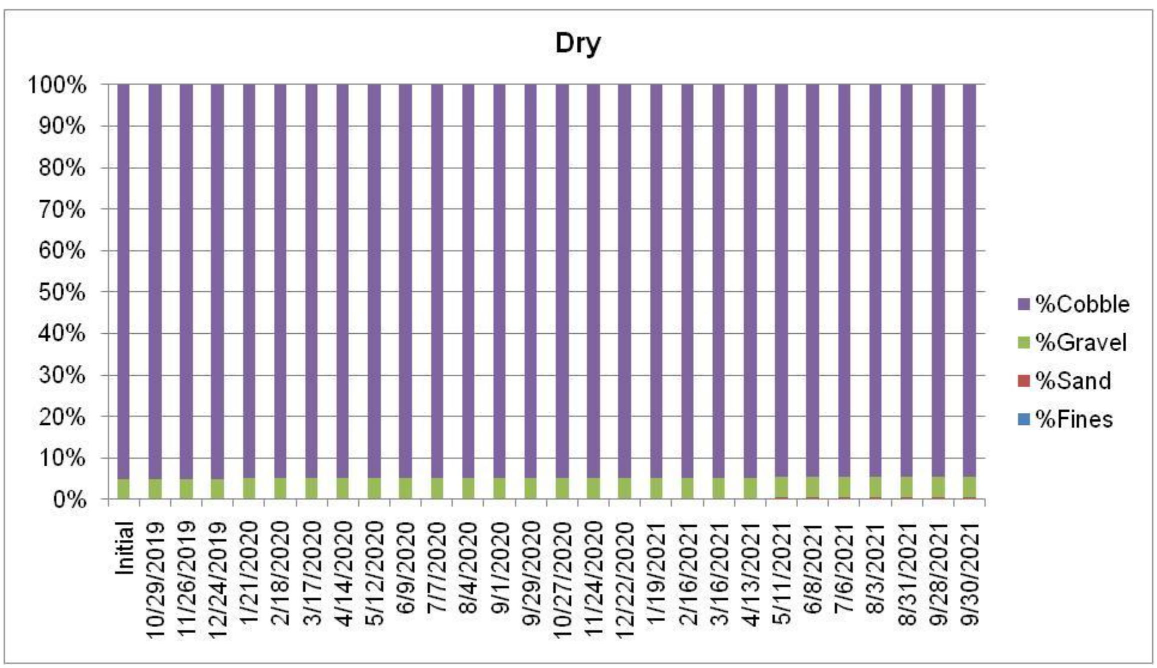
Source: Reclamation 2011.

Figure F1-10. Simulated Bed Composition Upstream of J.C. Boyle Reservoir during Two Successive Wet Water Years after Dam Removal



Source: Reclamation 2011.

Figure F1-11. Simulated Bed Composition Upstream of J.C. Boyle Reservoir during Two Successive Median Water Years after Dam Removal



Source: Reclamation 2011.

Figure F1-12. Simulated Bed Composition Upstream of J.C. Boyle Reservoir during Two Successive Dry Water Years after Dam Removal

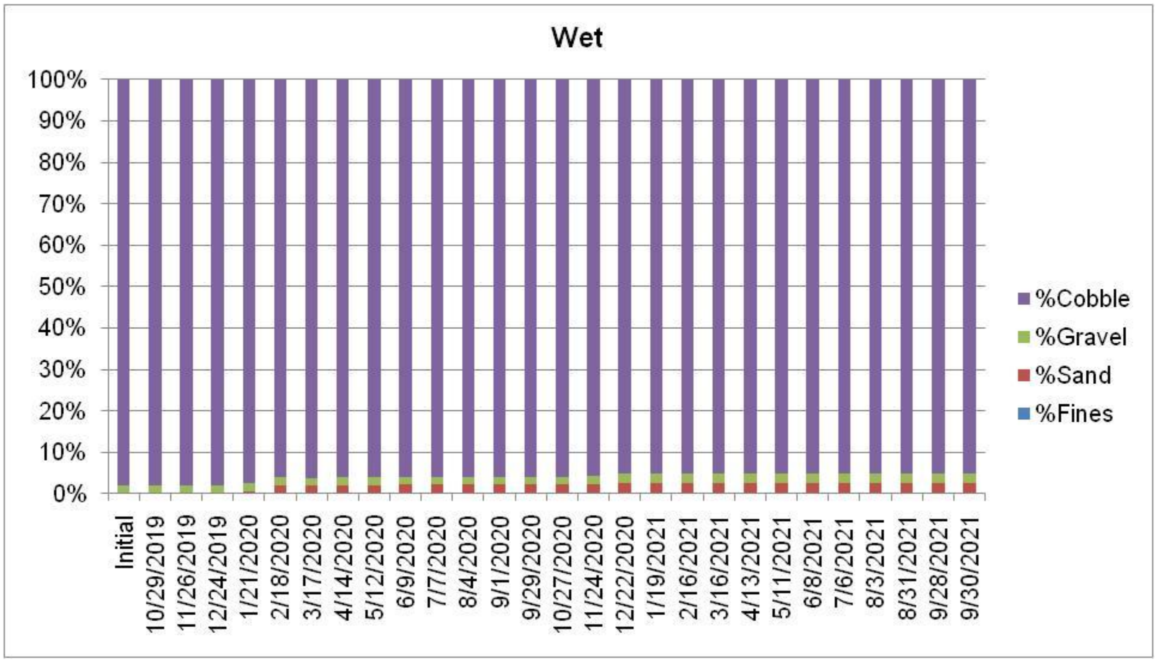
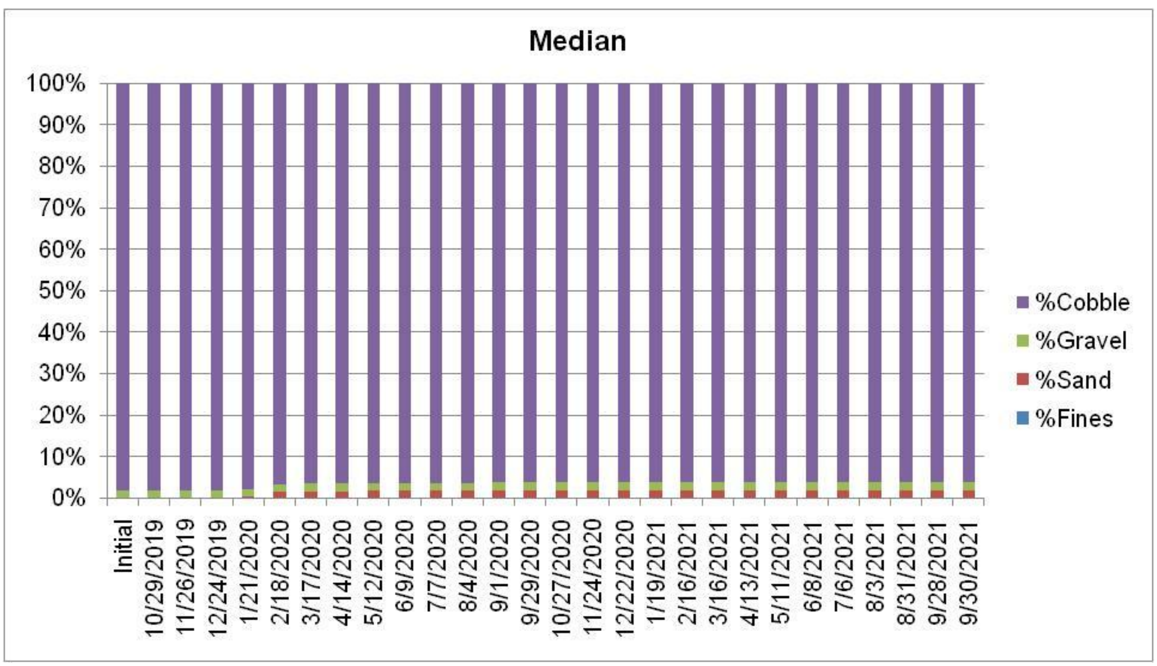
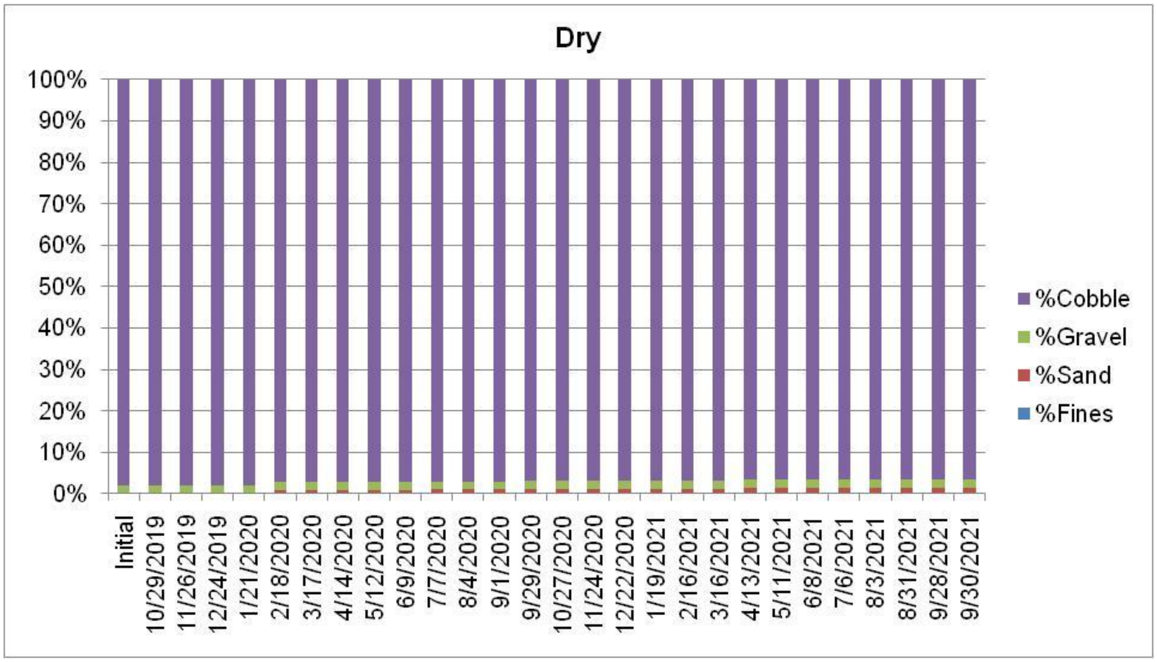


Figure F1-13. Simulated Bed Composition from J.C. Boyle to Copco 1 Reservoirs during Two Successive Wet Water Years after Dam Removal



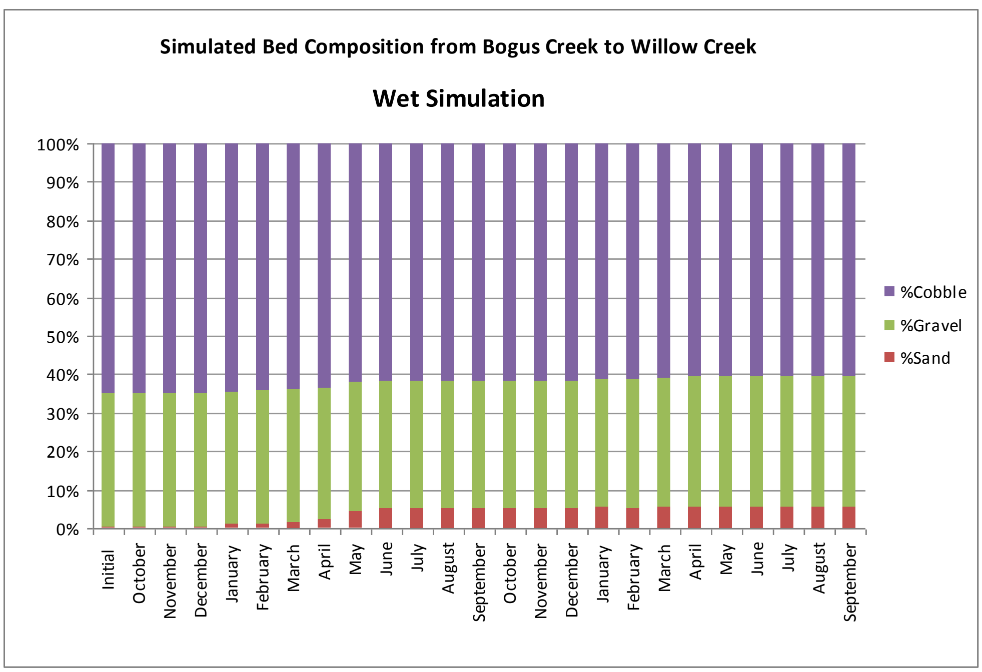
Source: Reclamation 2011.

Figure F1-14. Simulated Bed Composition from J.C. Boyle to Copco 1 Reservoirs during Two Successive Median Water Years after Dam Removal



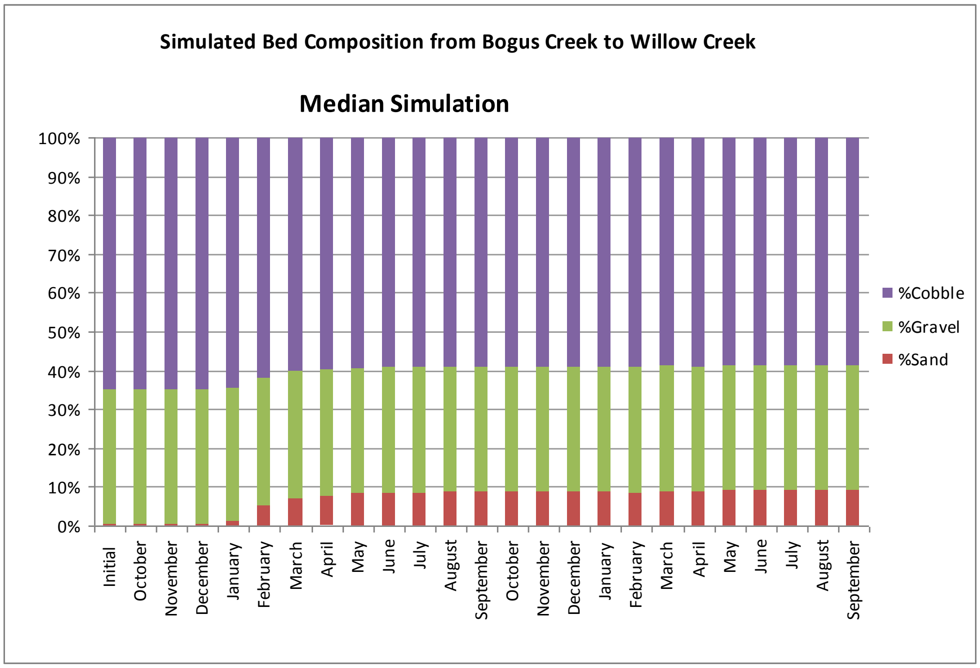
Source: Reclamation 2011.

Figure F1-15. Simulated Bed Composition from J.C. Boyle to Copco 1 Reservoirs during Two Successive Dry Water Years after Dam Removal



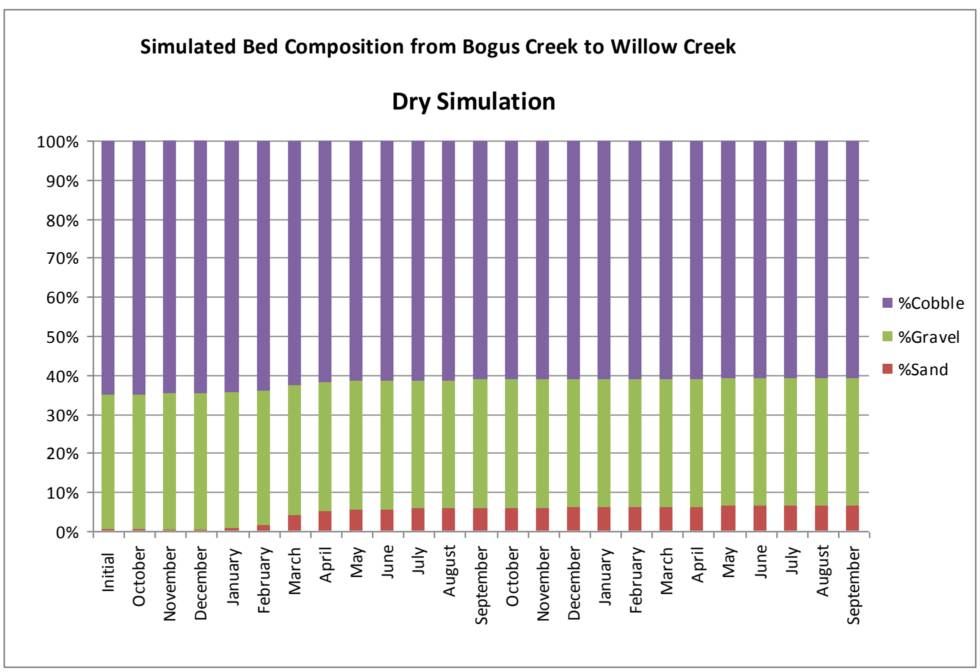
Source: Reclamation 2011.

Figure F1-16. Simulated Bed Composition from Bogus Creek to Willow Creek during Two Successive Wet Water Years after Dam Removal



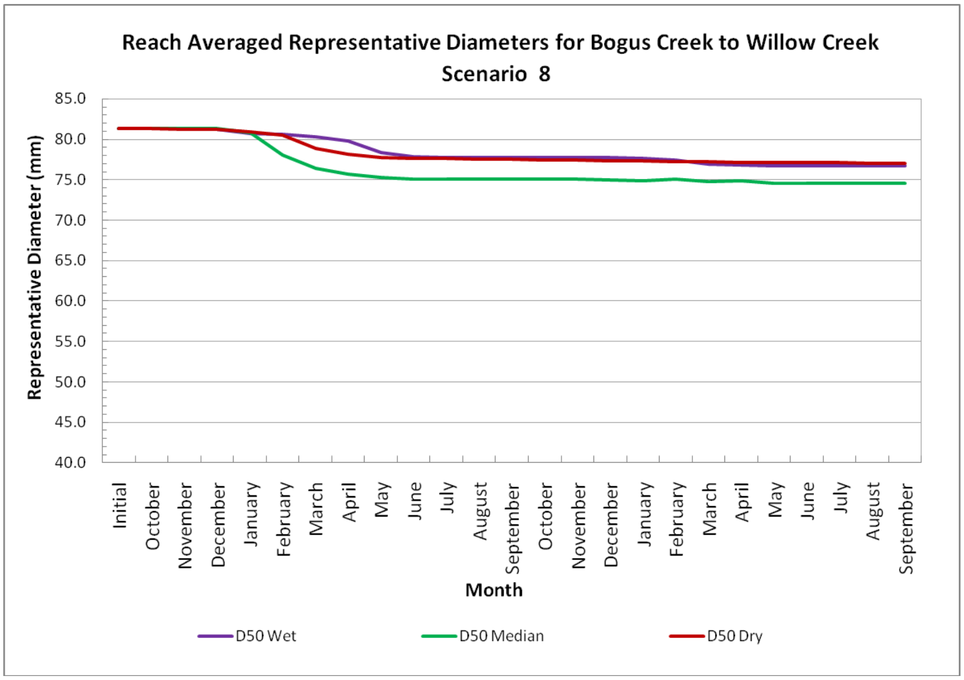
Source: Reclamation 2011.

Figure F1-17. Simulated Bed Composition from Bogus Creek to Willow Creek during Two Successive Median Water Years after Dam Removal



Source: Reclamation 2011.

Figure F1-18. Simulated Bed Composition from Bogus Creek to Willow Creek during Two Successive Dry Water Years after Dam Removal



Source: USBR 2011.

Figure F1-19. Simulated Bed Substrate Size from Bogus Creek to Willow Creek under successive wet, median, and dry years after Dam Removal

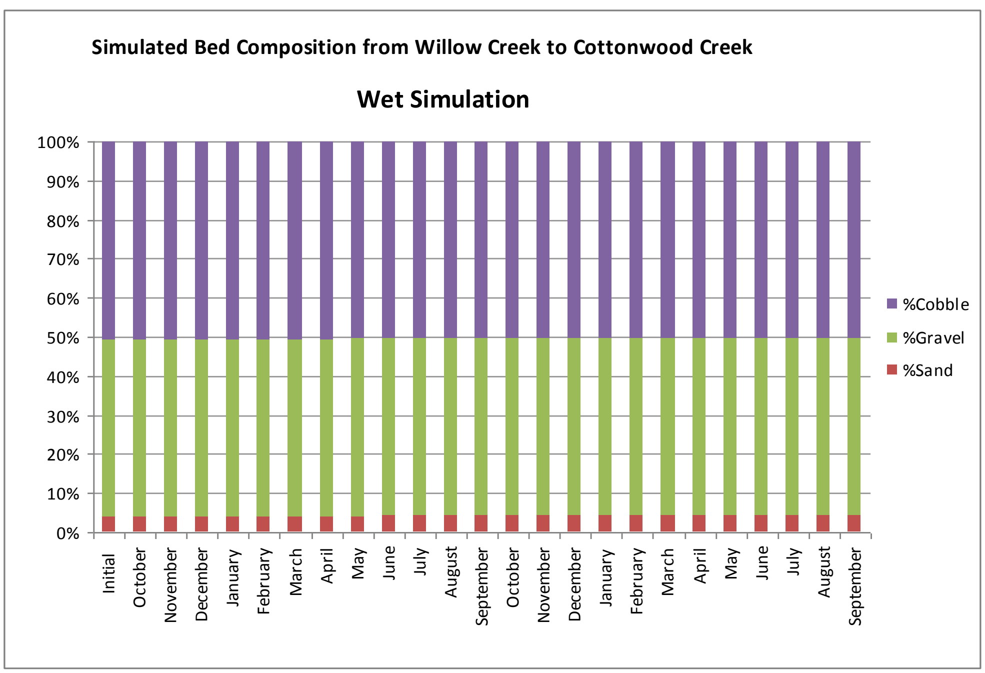
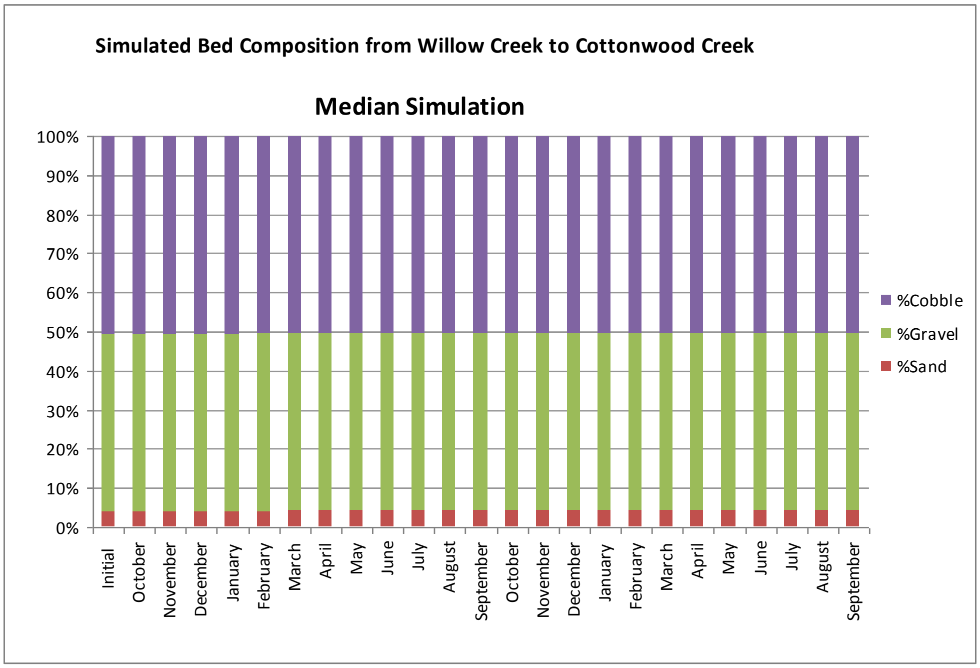
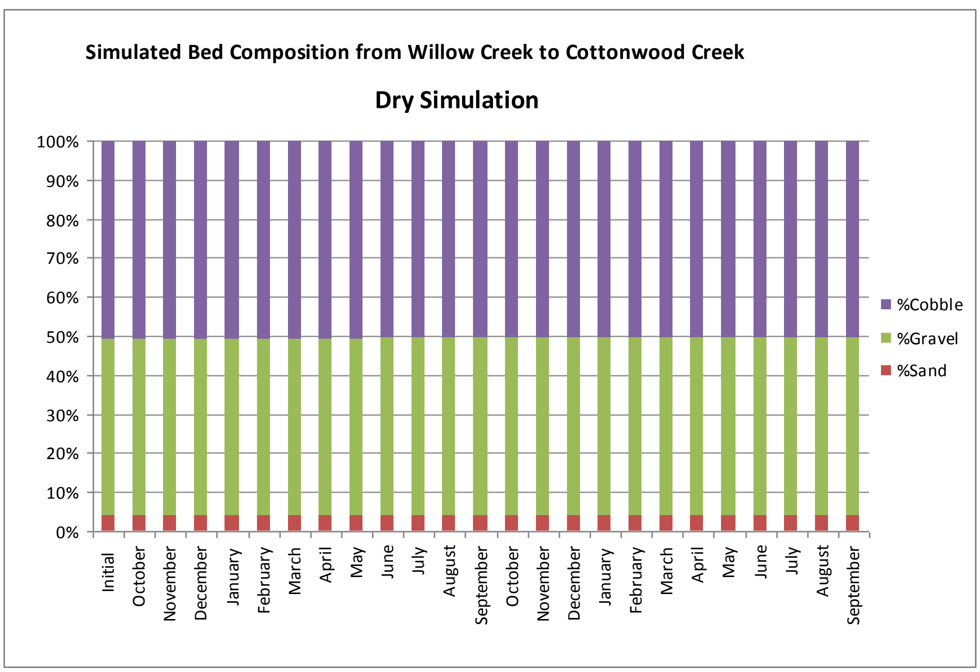


Figure F1-20. Simulated Bed Composition from Willow Creek to Cottonwood Creek during Two Successive Wet Water Years after Dam Removal



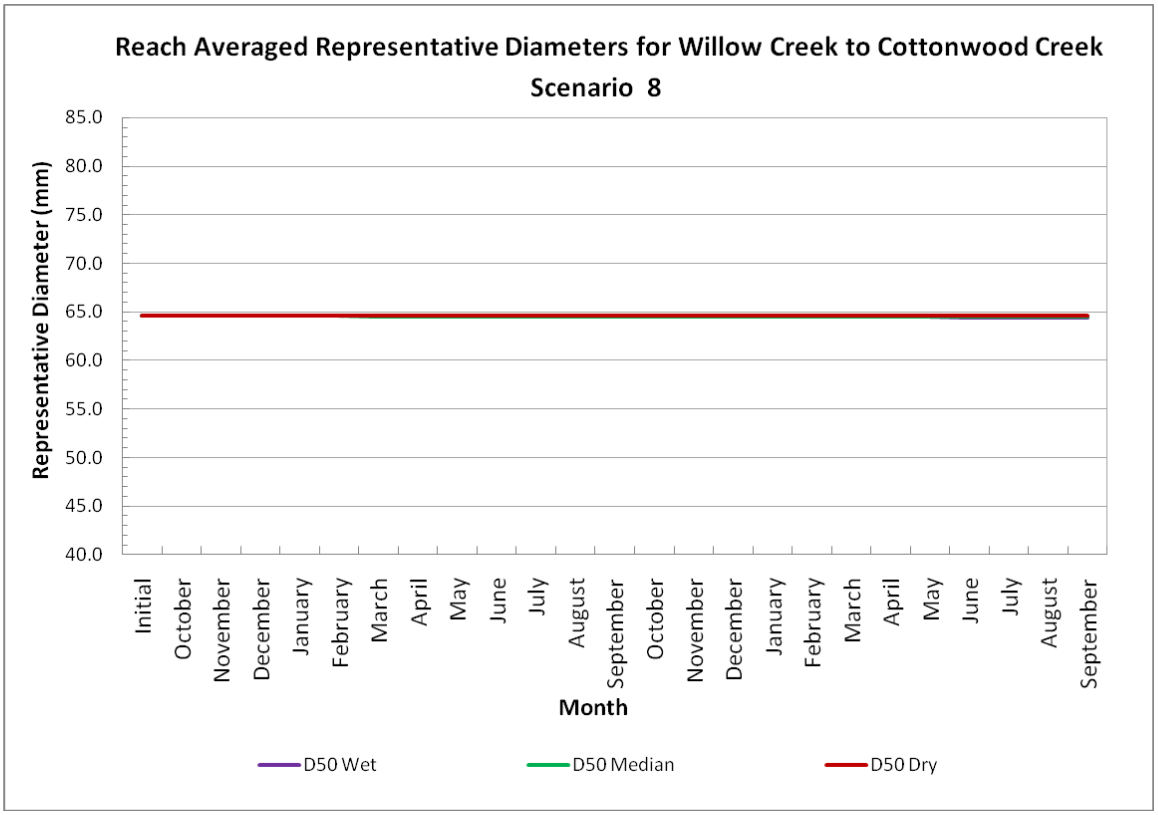
Source: Reclamation 2011.

Figure F1-21. Simulated Bed Composition from Willow Creek to Cottonwood Creek during Two Median Water Years after Dam Removal



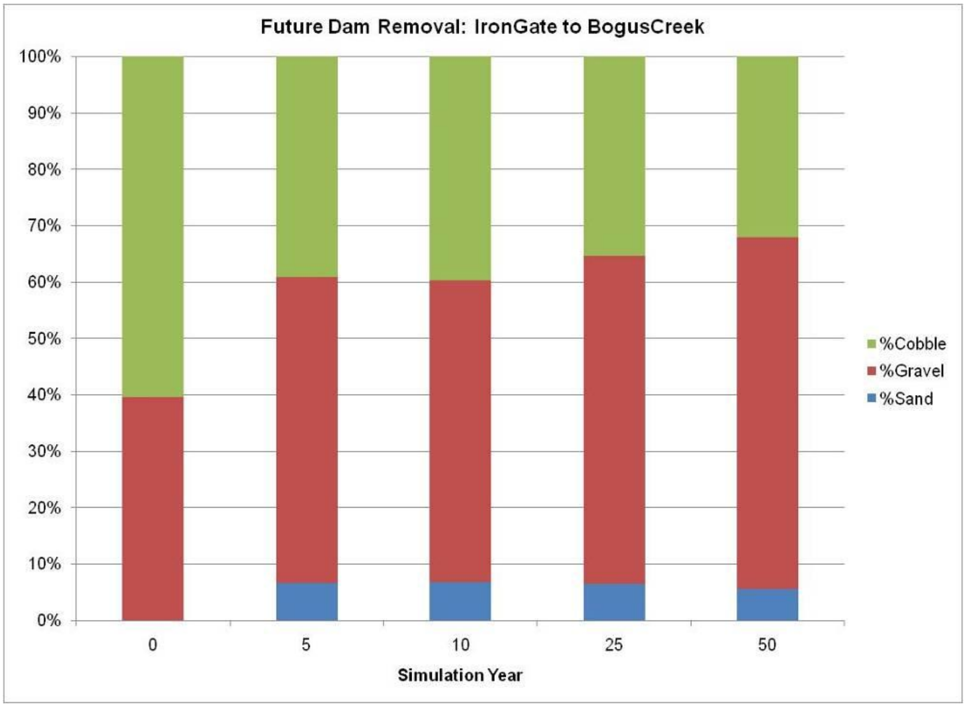
Source: Reclamation 2011.

Figure F1-22. Simulated Bed Composition from Willow Creek to Cottonwood Creek during Two Dry Water Years after Dam Removal



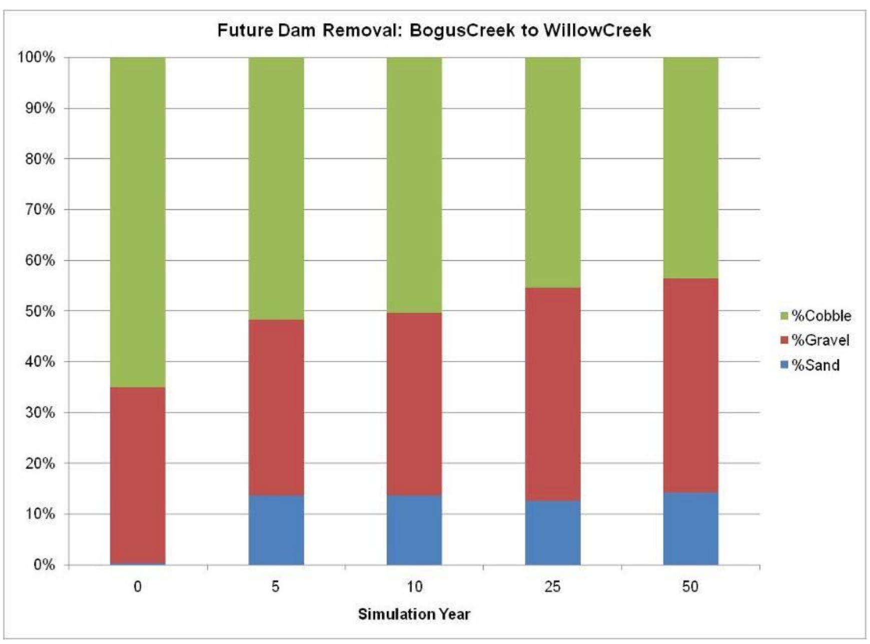
Source: USBR 2011.

Figure F1-23. Simulated Bed Substrate Size from Willow Creek to Cottonwood Creek under successive wet, median, and dry years after Dam Removal



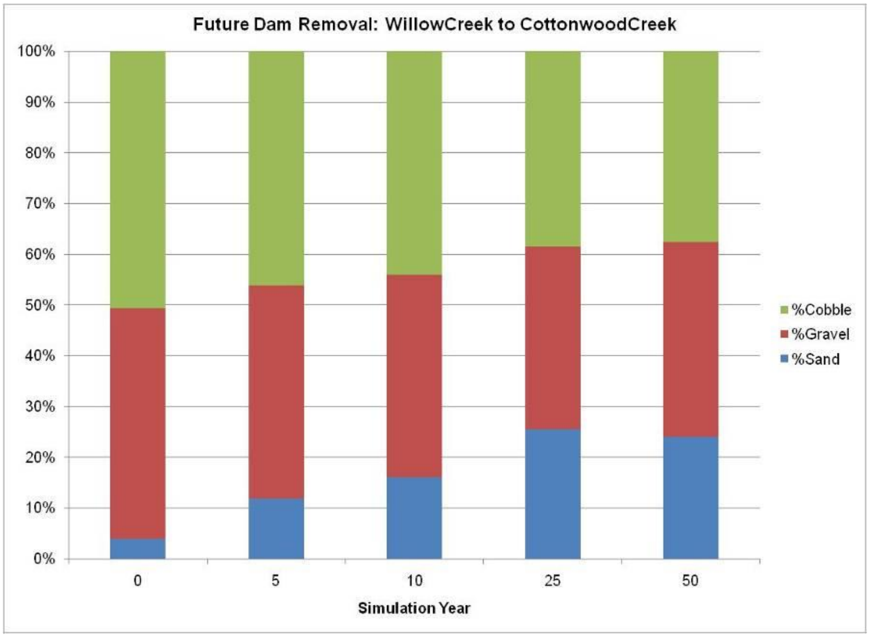
Source: USBR 2011.

Figure F1-24. Simulated Bed Composition of Iron Gate Dam to Bogus Creek Reach 5, 10, 25, and 50 Years after Dam Removal



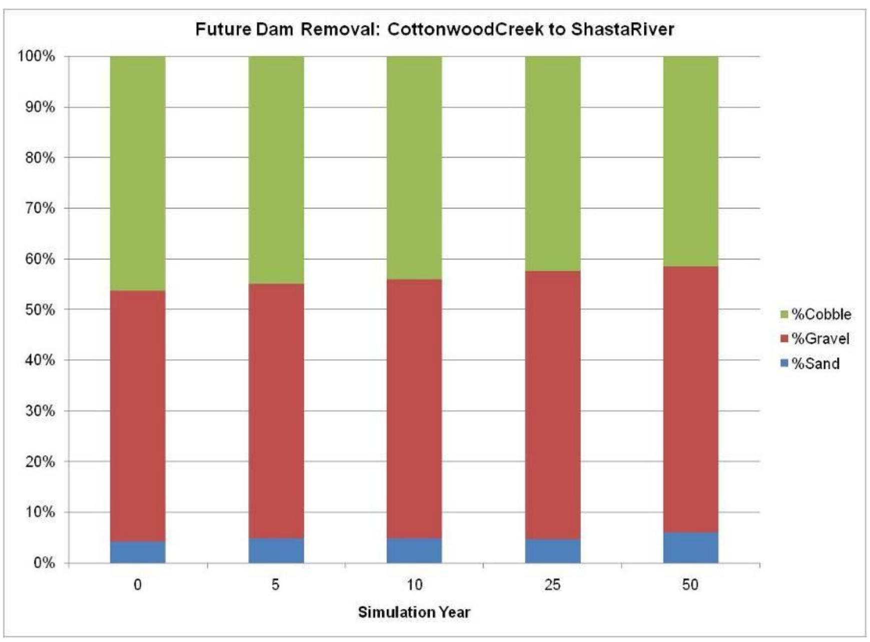
Source: USBR 2011.

Figure F1-25. Simulated Bed Composition of Bogus Creek to Willow Creek Reach 5, 10, 25, and 50 Years after Dam Removal



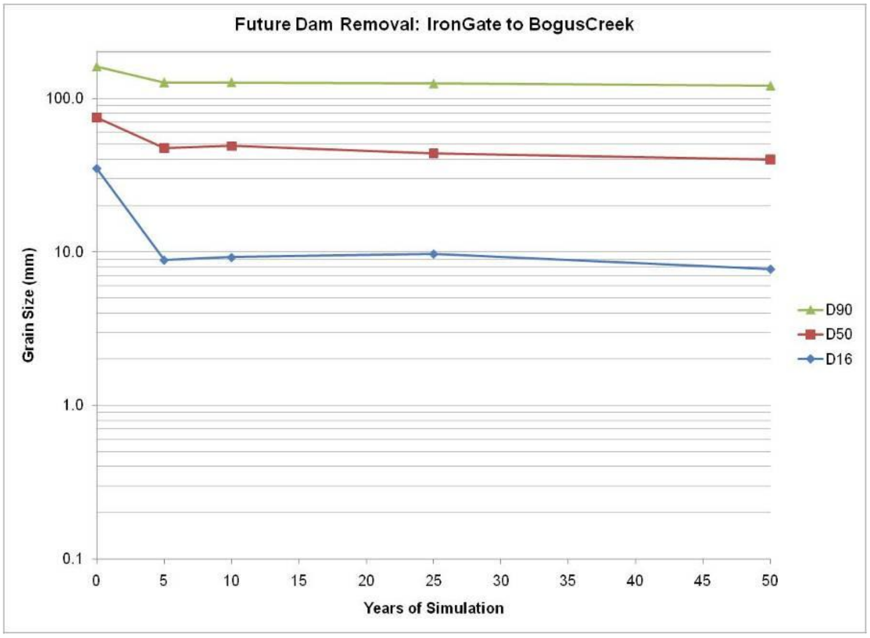
Source: USBR 2011.

Figure F1-26. Simulated Bed Composition of Willow Creek to Cottonwood Creek Reach 5, 10, 25, and 50 Years after Dam Removal



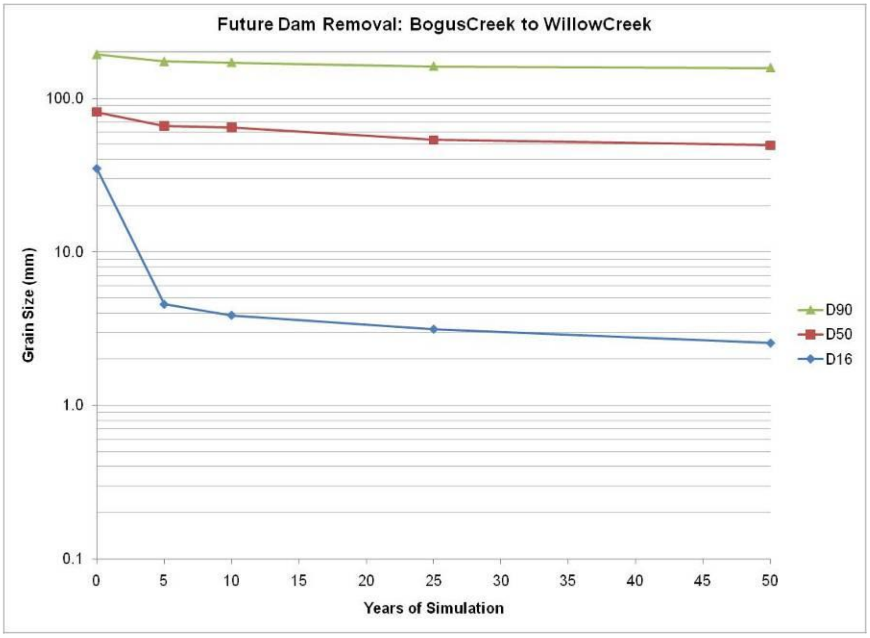
Source: USBR 2011.

Figure F1-27. Simulated Bed Composition of Cottonwood Creek to Shasta River Reach 5, 10, 25, and 50 Years after Dam Removal



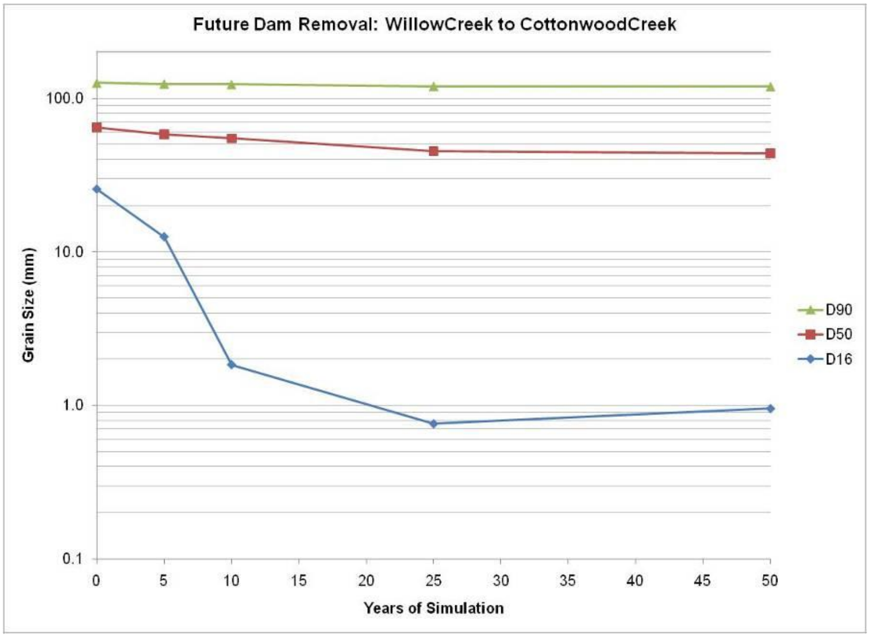
Source: USBR 2011.

Figure F1-28. Simulated Bed Substrate Size from Iron Gate Dam to Bogus Creek 5, 10, 25, and 50 Years after Dam Removal



Source: USBR 2011.

Figure F1-29. Simulated Bed Substrate Size from Bogus Creek to Willow Creek 5, 10, 25, and 50 Years after Dam Removal



Source: USBR 2011.

Figure F1-30. Simulated Bed Substrate Size from Willow Creek to Cottonwood Creek 5, 10, 25, and 50 Years after Dam Removal

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Appendix G
Vegetation Communities and Habitat Types Mapped by PacifiCorp

This appendix provides information on vegetation communities and habitat types mapped by PacifiCorp and originally documented in:

> *Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February, 2004.*

During fall and winter 2001-2002, PacifiCorp developed a vegetation classification system for creating a preliminary vegetation map with input from the Terrestrial Resources Work Group (TRWG). The classification system was based on the California Wildlife Habitat Relations System (CWHRS) and the National Wetland Inventory (NWI) classification schemes.

During fall 2001, PacifiCorp delineated polygons on aerial and infrared photos and U.S. Geological Survey (USGS) digital orthoquads and classified vegetation within each polygon using the floristic/structural vegetation classification scheme. Vegetation mapping was verified in the field, with a particular focus on riparian and wetland habitats. In addition, 295 of the 2,900 polygons were sampled in August and September of 2002. Data collected during vegetation sampling included aerial foliar cover by cover class for each species in each of the vegetation layers (i.e., tree, shrub, and herb layers); the areal cover and height of each vegetation layer in the plot; the aspect; and the slope. In addition, the number of living trees was tallied and the tree diameters at breast height (dbh) were recorded, and the amount of dead wood in the plot was assessed by collecting data on coarse woody debris (CWD), snags, and wood cover for pieces greater than 4 inches (10 centimeters [cm]) in diameter. General observations were made regarding erosion, livestock, and recreation, and their effects on the habitat.

In conjunction with the study described above, PacifiCorp conducted an extensive assessment of wetland and riparian areas in 2002 and 2003. Representative riparian/ wetlands transects were sampled at reservoirs and river reaches throughout the PacifiCorp study area. Transects were positioned perpendicular to the flow of the river or reservoir shoreline at a depth in the channel sufficient to capture the low elevation edge of submerged and emergent vegetation or unvegetated shoreline habitat and to span the full width of the riparian/wetland vegetation and up to the upland-riparian zone. Riparian and wetland sampling data were collected in 1,135 plots distributed among 113 sampling sites in the 11 Project sections of the study area.

The wetland and riparian assessment included the characterization and quantification of wetland and riparian vegetation for each reservoir and river reach within the study area; documentation of flow, hydrology, and benthic substrate, and characterization of wetland and riparian habitat quality.

Vegetation communities and habitat types documented in 2002 in the PacifiCorp Study are shown in Table G-1. Vegetation cover and sampling locations are shown in Figures G-1 through G-18.

Table G-1. Vegetation Communities and Habitat Types Documented in 2002 in the PacifiCorp Study (2004).

Vegetation Cover Type	Description of Cover Type within Study Area	Location in Study Area
Upland Tree Habitats	More than 10 percent total cover by tree species	
Montane Hardwood Oak	Moderately open tree canopy, moderately dense shrub layer, moderately dense herbaceous layer. Yellow starthistle (*Centaurea solstitialis*) and medusahead (*Taeniatherum caput-medusae*) occur in about 25 percent of stands in the project vicinity.	Most abundant around Iron Gate Reservoir, Copco Reservoir, and along J.C. Boyle peaking reach.
Montane Hardwood Oak-Conifer	Dense tree cover, sparse shrub layer, moderately open herbaceous layer.	Most abundant along the J.C. Boyle peaking and bypass reaches, at Copco Reservoir, at Fall Creek, and along Copco 2 bypass reach.
Montane Hardwood Oak-Juniper	Open tree layer, sparse shrub layer, dense herbaceous layer. Yellow starthistle and medusahead occur in about 25 percent of stands, primarily around Iron Gate and Copco Reservoirs and along Copco 2 bypass reach.	Most abundant cover type in the project vicinity.
Juniper	Open canopy, shrub layer varies from sparse to dense, herbaceous layer ranges from sparse to dense.	Most abundant along Link River and along J.C. Boyle peaking reach.
Mixed Conifer	Dense tree cover is often two-layered, open shrub layer, moderately sparse herbaceous layer.	Approximately 70 percent of stands are along J.C. Boyle bypass reach.
Lodgepole Pine	Sparse tree layer, sparse shrub layer, dense herbaceous layer.	Lodgepole pine stands occur along J.C. Boyle bypass reach and at J.C. Boyle Reservoir as a result of replanting following timber harvest.
Ponderosa Pine	Moderate canopy cover, relatively sparse shrub cover, moderately open herbaceous layer.	Most abundant along Keno reach and at J.C. Boyle Reservoir.
Upland Shrub Habitats	More than 10 percent total cover by shrub species and less than 10 percent total cover by tree species.	
Mixed Chaparral	Requires occurrence of two or more shrub species, each covering 5 percent or more of the area. Very few trees, moderate shrub layer, herbaceous layer varies from sparse to dense.	Approximately 60 percent occurs along J.C. Boyle bypass reach and around Copco Reservoir.
Rabbitbrush	Gray rabbitbrush (*Ericameria nauseosa*) is the dominant shrub species in most areas and Sierra plum (*Prunus subcordata*) is the only other shrub species present. Applegate's milk-vetch (*Astragalus applegatei*), a federally endangered plant species, grows in a seasonally moist site with rabbitbrush and saltgrass (*Distichlis spicata*) along Keno Impoundment.	Occurs at Keno Impoundment and along Keno reach.
Sagebrush	Moderately dense shrub layer, sparse herbaceous layer.	This limited habitat type occurs near Keno Impoundment and J.C. Boyle Reservoirs.

Table G-1. Vegetation Communities and Habitat Types Documented in 2002 in the PacifiCorp Study (2004).

Vegetation Cover Type	Description of Cover Type within Study Area	Location in Study Area
Upland Herb Habitats	More than 2 percent total cover by herbaceous species and less than 10 percent total cover of tree and/or shrub species.	
Annual Grassland	Total shrub cover is less than 1 percent. Nine of the 11 most frequent herbaceous species are introduced species; two of them are the exotic/invasive species medusahead and yellow starthistle. Cheatgrass (*Bromus tectorum*) is relatively more abundant in annual grasslands along Keno Impoundment and along J.C. Boyle bypass reach. Medusahead, hairy brome (*Bromus ramosus*), and yellow starthistle dominate grasslands downriver of J.C. Boyle peaking reach.	More than 88 percent of the annual grasslands occur along J.C. Boyle peaking reach and around Copco and Iron Gate Reservoirs.
Perennial Grassland	Sparse shrub cover includes a wide variety of species. 31 graminoid species occur: 5 introduced annuals, 11 introduced perennials, 2 native annuals, 10 native perennials, 1 native rush, and 2 native sedges.	More than 87 percent occurs around J.C. Boyle Reservoir and in the J.C. Boyle peaking and bypass reaches.
Wetland Habitats		
Palustrine Emergent	Dense herbaceous layer, often with a weedy zone immediately upslope of the bulrush (*Scirpus* spp.) zone. Short-podded thelypody (*Thelypodium brachycarpum*), a special status species, occurs in this habitat type at Keno Impoundment.	More than 88 percent occurs adjacent to Keno Impoundment, where wetlands associated with the Klamath Wildlife Area and the undiked wetlands southwest of the Klamath Wildlife Area are located. The largest single emergent wetland associated with the project covers more than 63 acres and is near Sportsman's Park at J.C. Boyle Reservoir.
Palustrine Scrub-Shrub	Open canopy with moderate shrub layer. Coyote willow (*Salix exigua*, also known as narrowleaf willow) and arroyo willow (*Salix lasiolepis*) are the primary hydrophilic shrubs. Arroyo willow is more abundant upriver and upslope. The only shrub layer species in the Link River wetland is arroyo willow; this species was most frequent at Keno Impoundment, J.C. Boyle Reservoir, and Fall Creek. Species dominating the Spencer Creek wetland include arroyo willow and coyote willow. Arroyo willow also occurred in the Fall Creek reach. Coyote willow is the dominant shrub layer species in 75 percent of the wetlands from J.C. Boyle Reservoir to Iron Gate Reservoir.	More than 80 percent occurs adjacent to J.C. Boyle, Copco, and Iron Gate Reservoirs.

Table G-1. Vegetation Communities and Habitat Types Documented in 2002 in the PacifiCorp Study (2004).

Vegetation Cover Type	Description of Cover Type within Study Area	Location in Study Area
Palustrine Forested	Dense tree cover includes the primarily hydrophilic tree species coyote willow and shining willow (*Salix lucida*); weeping willow (*Salix babylonica*) is the dominant tree layer species in one of the Keno Impoundment wetlands. The two Keno Impoundment wetlands have no shrub layer. Brown dogwood (*Cornus glabrata*) and arroyo willow are the only species in the open shrub layer of the two wetlands along Copco 2 bypass reach. Wetlands at Copco and Iron Gate Reservoirs have an open shrub layer with coyote willow.	More than 80 percent occurs adjacent to Copco and Iron Gate Reservoirs.
Palustrine Aquatic Bed	Dominant species are pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum demersum*).	Occurs in all project reservoirs and slow moving sections of the Klamath River.
Riparian Habitats		
Riparian Grassland	Dense herbaceous cover.	Reed canarygrass (*Phalaris arundinacea*) is relatively common along Link River, along Keno reach, and along J.C. Boyle peaking reach.
Riparian Shrub	Coyote willow, arroyo willow, and Oregon ash (*Fraxinus latifolia*) saplings are the primary hydrophilic shrubs. Dense herbaceous cover is dominated by reed canarygrass along Link River, Keno reach, J.C. Boyle bypass reach, and J.C. Boyle peaking reach.	J.C. Boyle peaking reach and Klamath River from Iron Gate development to Shasta River are the locations with the most riparian shrub habitat.
Riparian Deciduous	Moderate canopy cover includes coyote willow. Moderate shrub and herb layers.	Occurs primarily along J.C. Boyle peaking reach and along the Klamath River from Iron Gate development to Shasta River.
Riparian Mixed Deciduous-Coniferous	A total of 8 tree, 12 shrub, and 49 herbaceous plant species were documented in this habitat. Dense tree layer, moderate shrub layer, open herbaceous layer. A taller herb layer with reed canarygrass and devil's beggarstick (*Bidens frondosa*) is often present along the river.	37.8 acres are mapped at Fall Creek, 12.0 acres along J.C. Boyle peaking reach, and 1.9 acres around Copco Reservoir.
Aquatic Habitats	The reservoirs represent 4,333 acres of lacustrine habitat in the PacifiCorp study area. Several reservoirs and river reaches have pockets of submerged aquatic vegetation that was not accounted for in this study.	
Riverine and Lacustrine Unconsolidated Bottom	Riverine unconsolidated bottom, which includes the semipermanently flooded flowing water of the Klamath River, totaled 726 acres.	
Riverine and Lacustrine Unconsolidated Shore	Riverine and lacustrine unconsolidated shoreline or gravel bar habitats cover 17.2 acres.	

Table G-1. Vegetation Communities and Habitat Types Documented in 2002 in the PacifiCorp Study (2004).

Vegetation Cover Type	Description of Cover Type within Study Area	Location in Study Area
Barren Habitats	Less than 2 percent total cover by herbaceous, desert, or nonwildland species; less than 10 percent cover by tree or shrub species.	
Rock Talus	Most rock talus habitats are barren with small patches of vegetation where the talus is thin or at the margins of the talus patch. 2 tree, 7 shrub, and 23 herbaceous plant species provided sparse cover in rock talus habitats.	Particularly abundant along J.C. Boyle peaking and bypass reaches.
Exposed Rock	A wide variety of species occurs in the sparse shrub and moderate herb layers.	Most abundant along J.C. Boyle peaking and bypass reaches and Copco 2 bypass reach; does not occur at Link River or Keno Impoundment.
Agricultural/Developed	More than 2 percent total vegetation cover is non-wildland vegetation. Includes three developed vegetation types: residential, recreational development, and industrial, where vegetation includes plants grown for landscaping. Also includes agricultural types such as pasture and irrigated hayfields, where vegetation includes plants grown for food and/or fiber.	Pastures and irrigated hayfields are distributed over 3,682 acres. More than 85 percent of the pasture/irrigated hayfield occurs around Keno Impoundment. J.C. Boyle peaking reach and the area along the Klamath River from Iron Gate development to Shasta River also have a substantial amount of pasture/irrigated hayfields.

Source: PacifiCorp 2004.

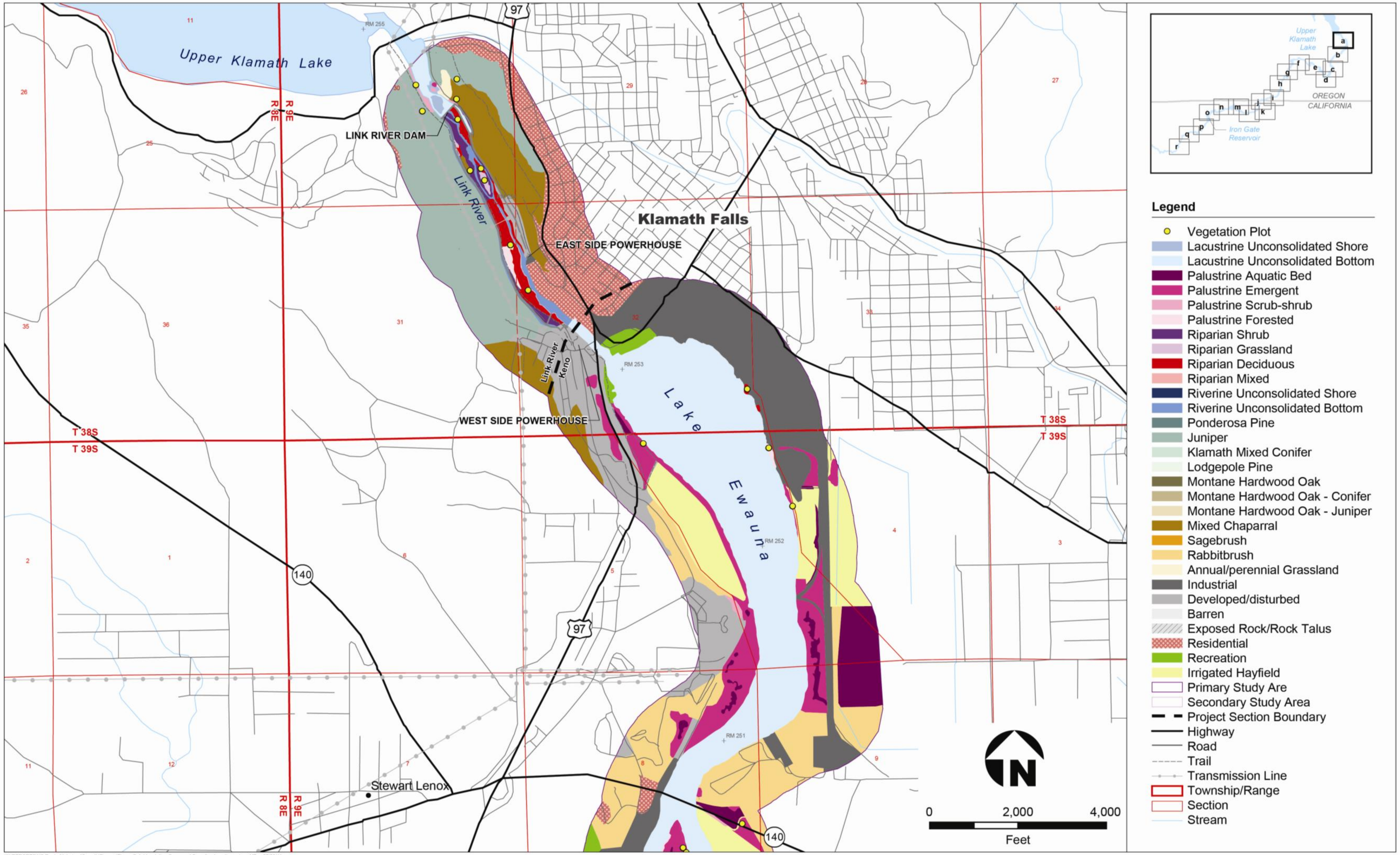


Figure G-1. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

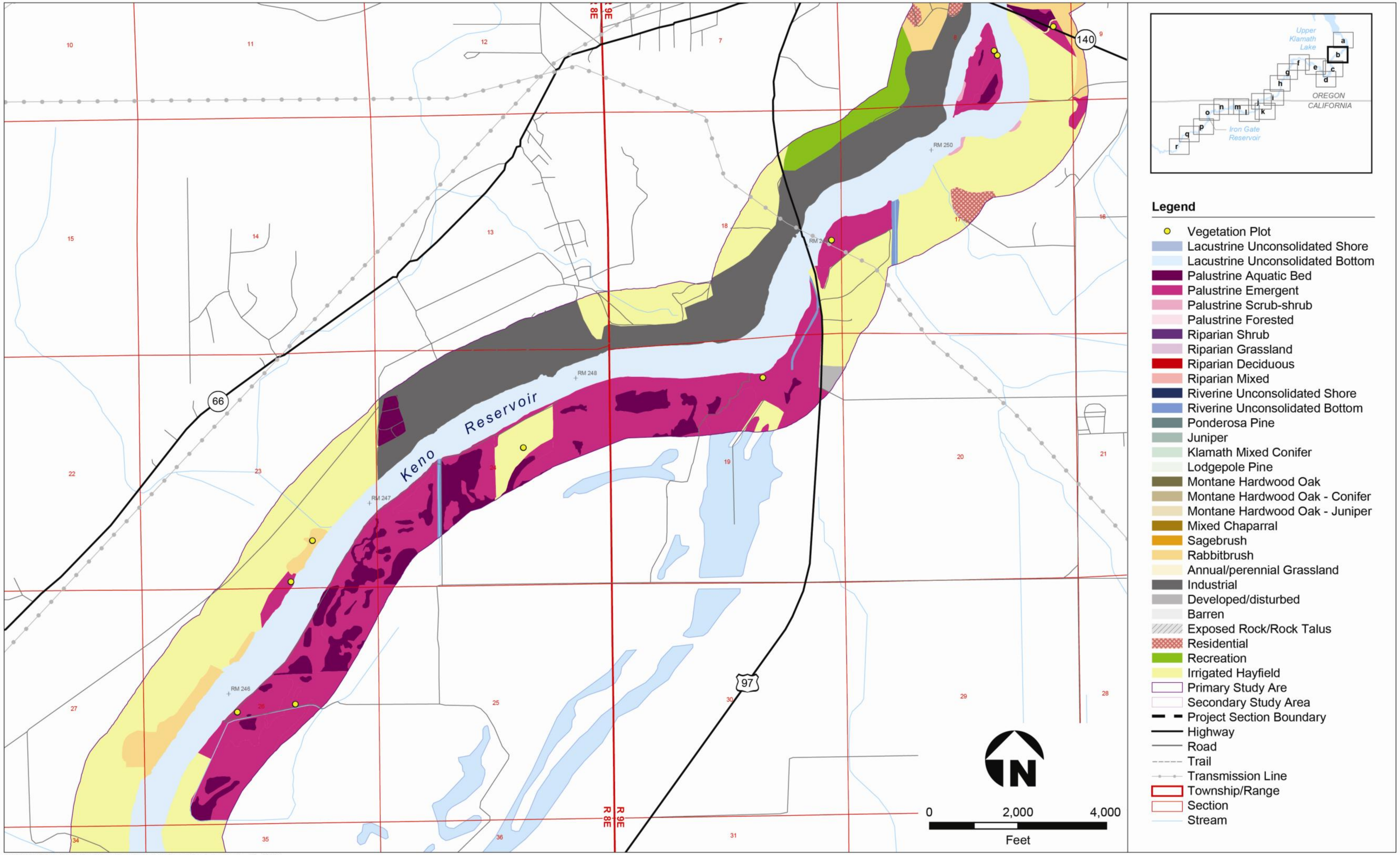
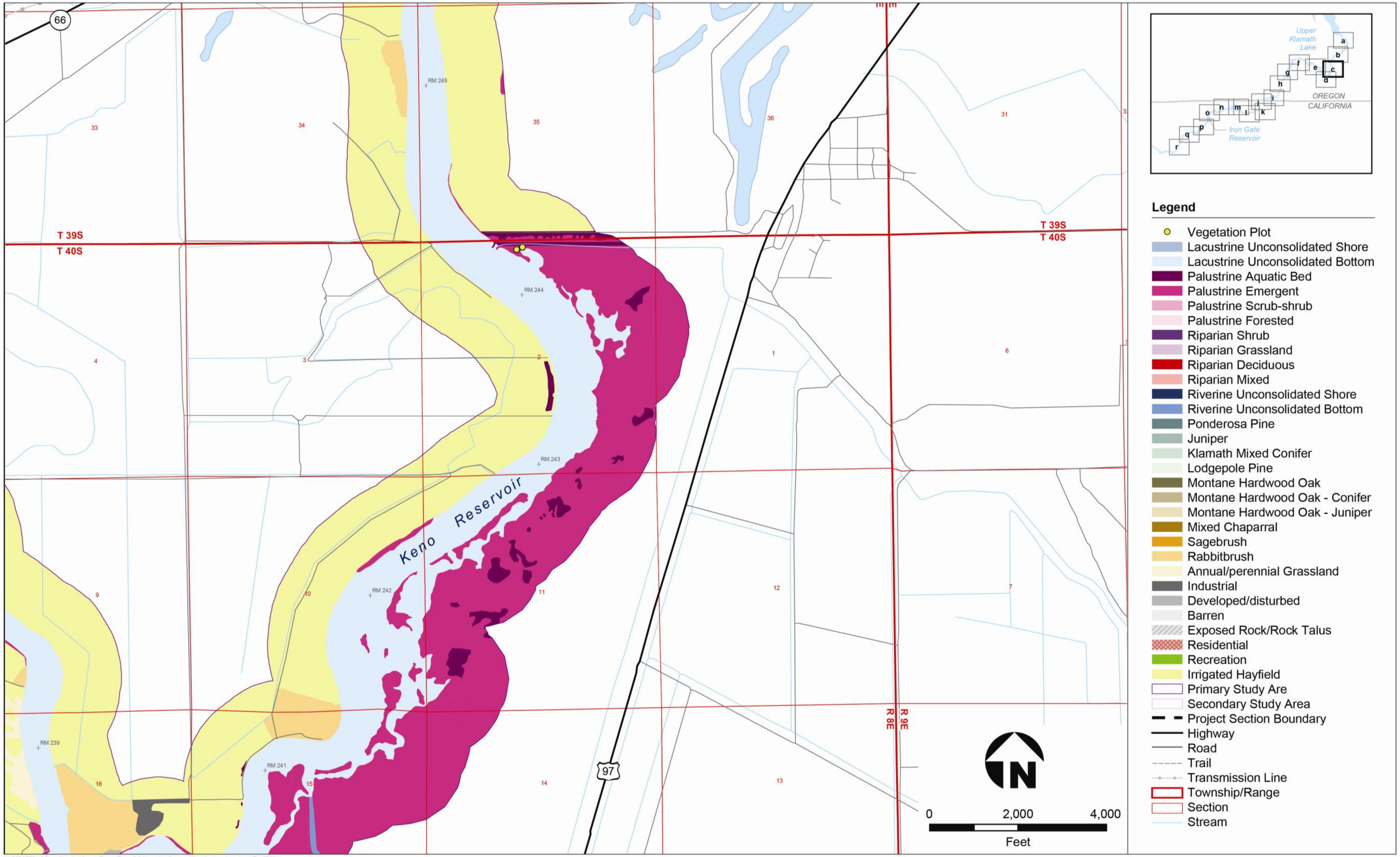


Figure G-2. Vegetation Cover and Sampling Locations (PacifiCorp 2004)



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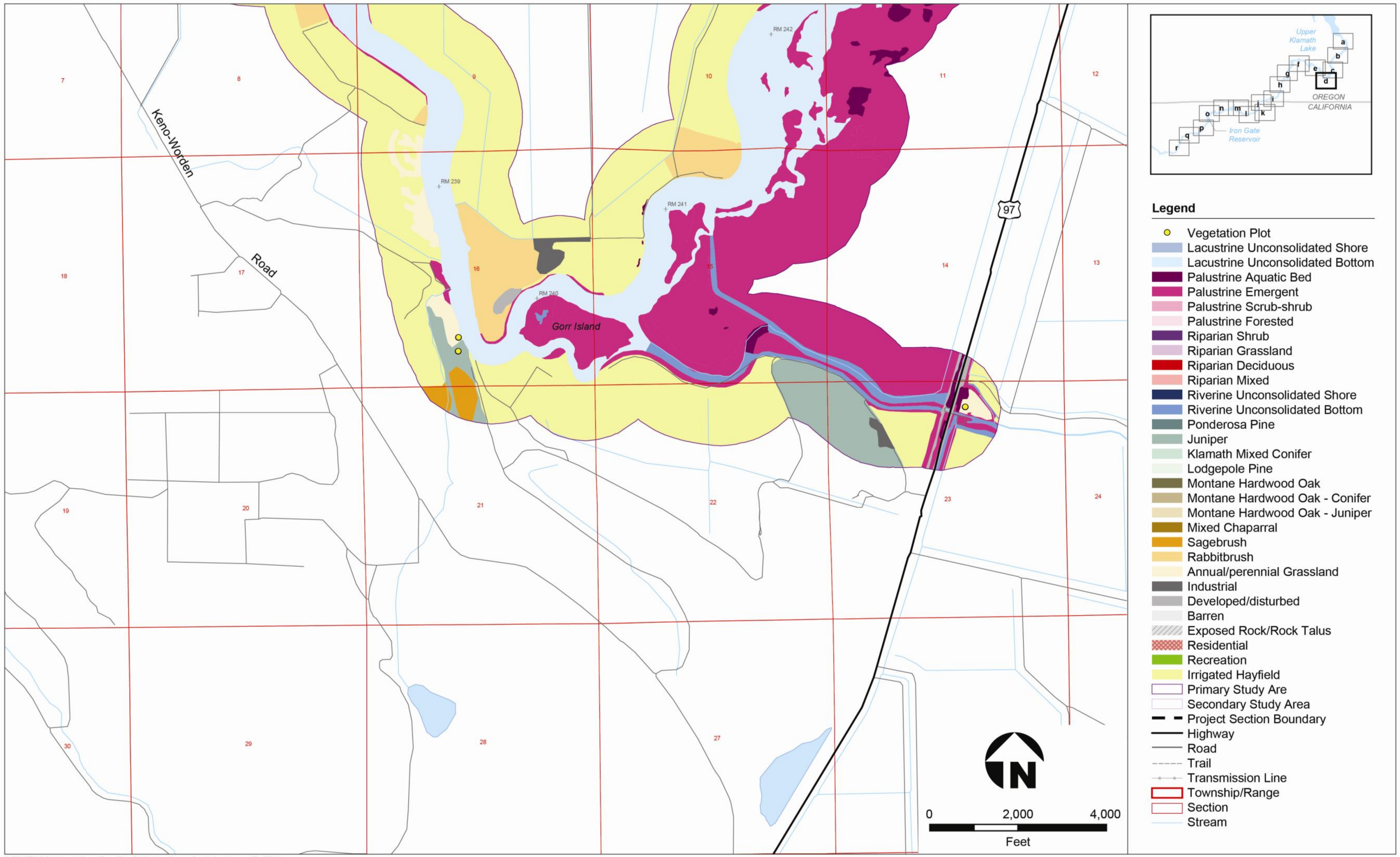

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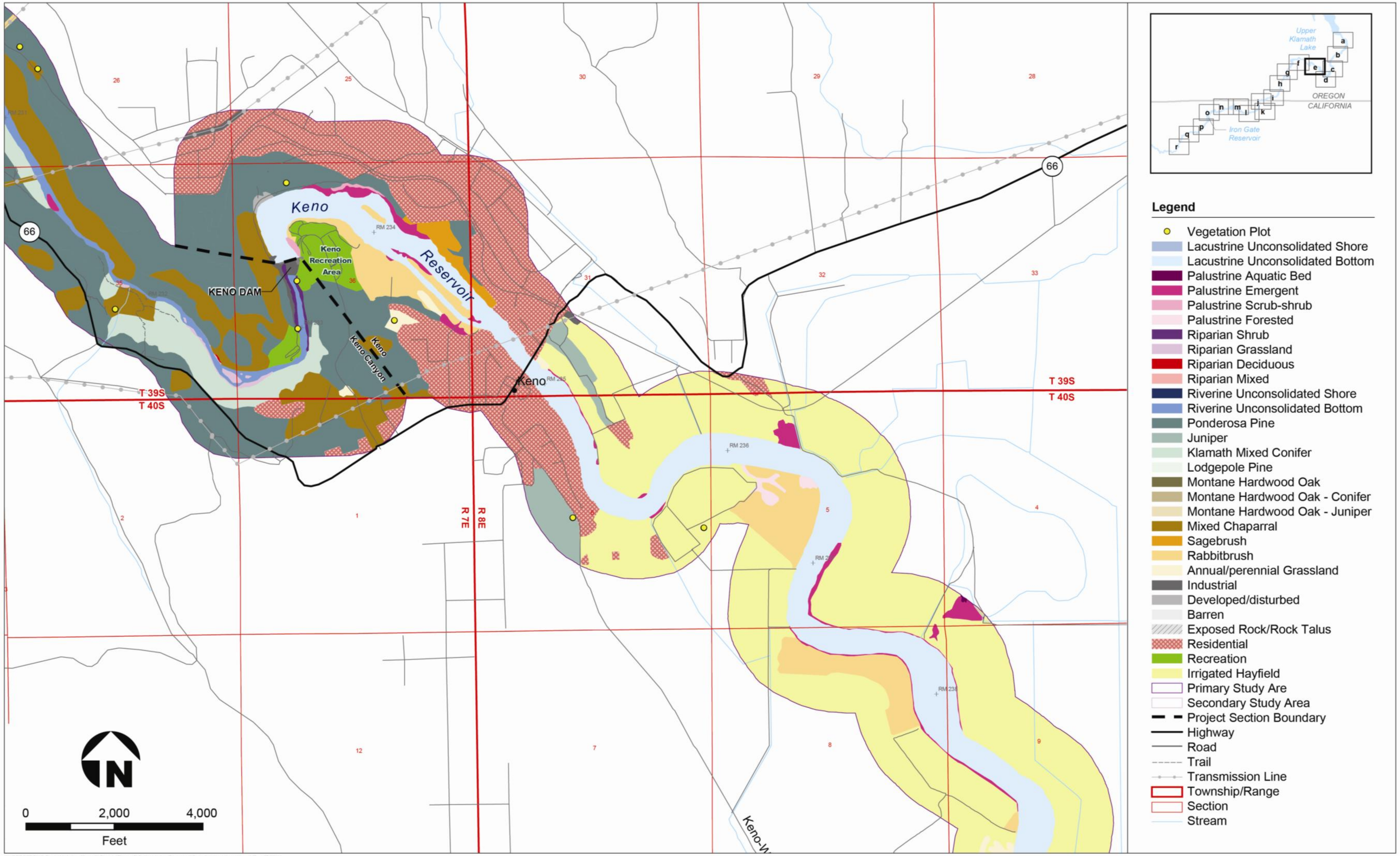

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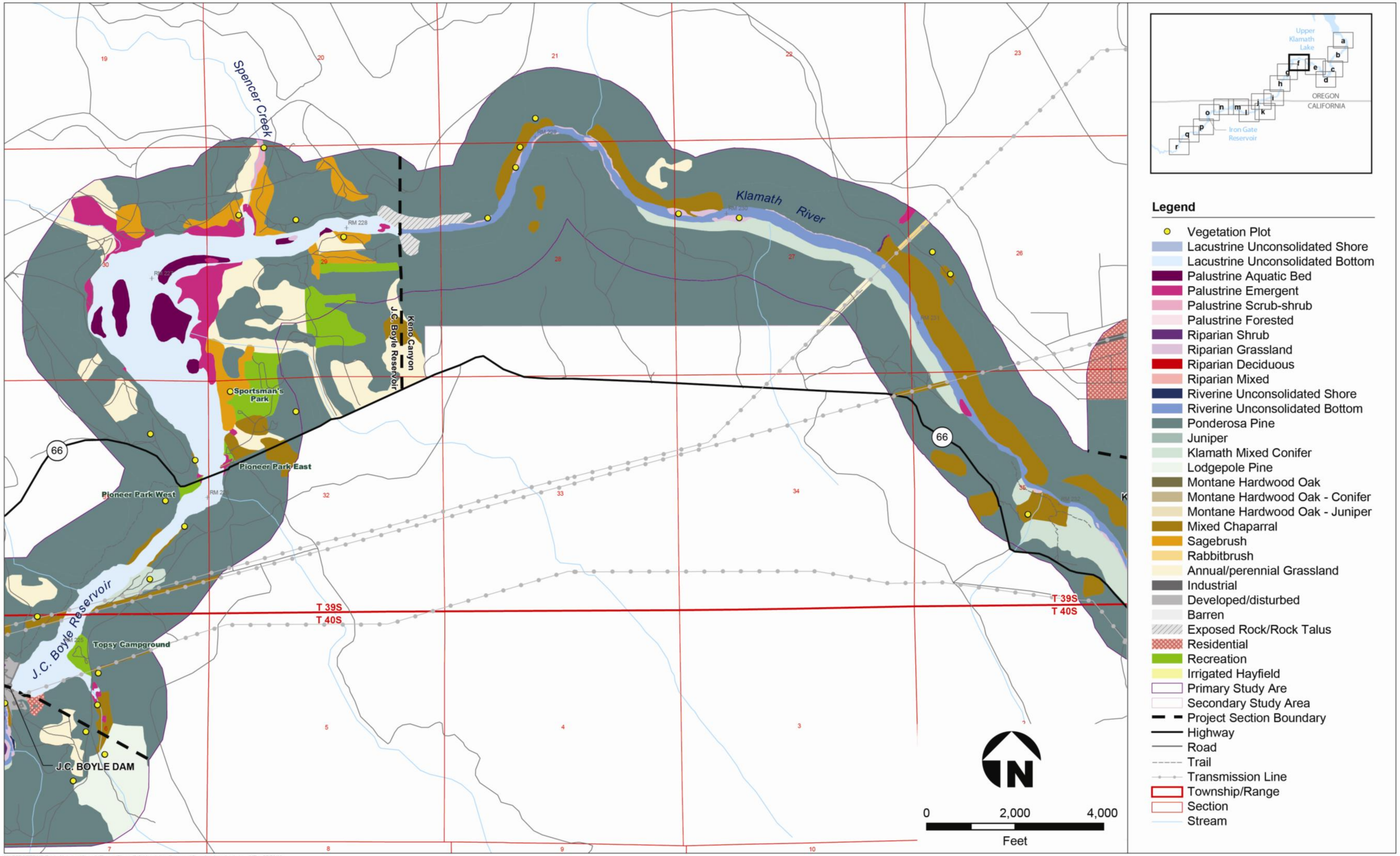


Figure G-6. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

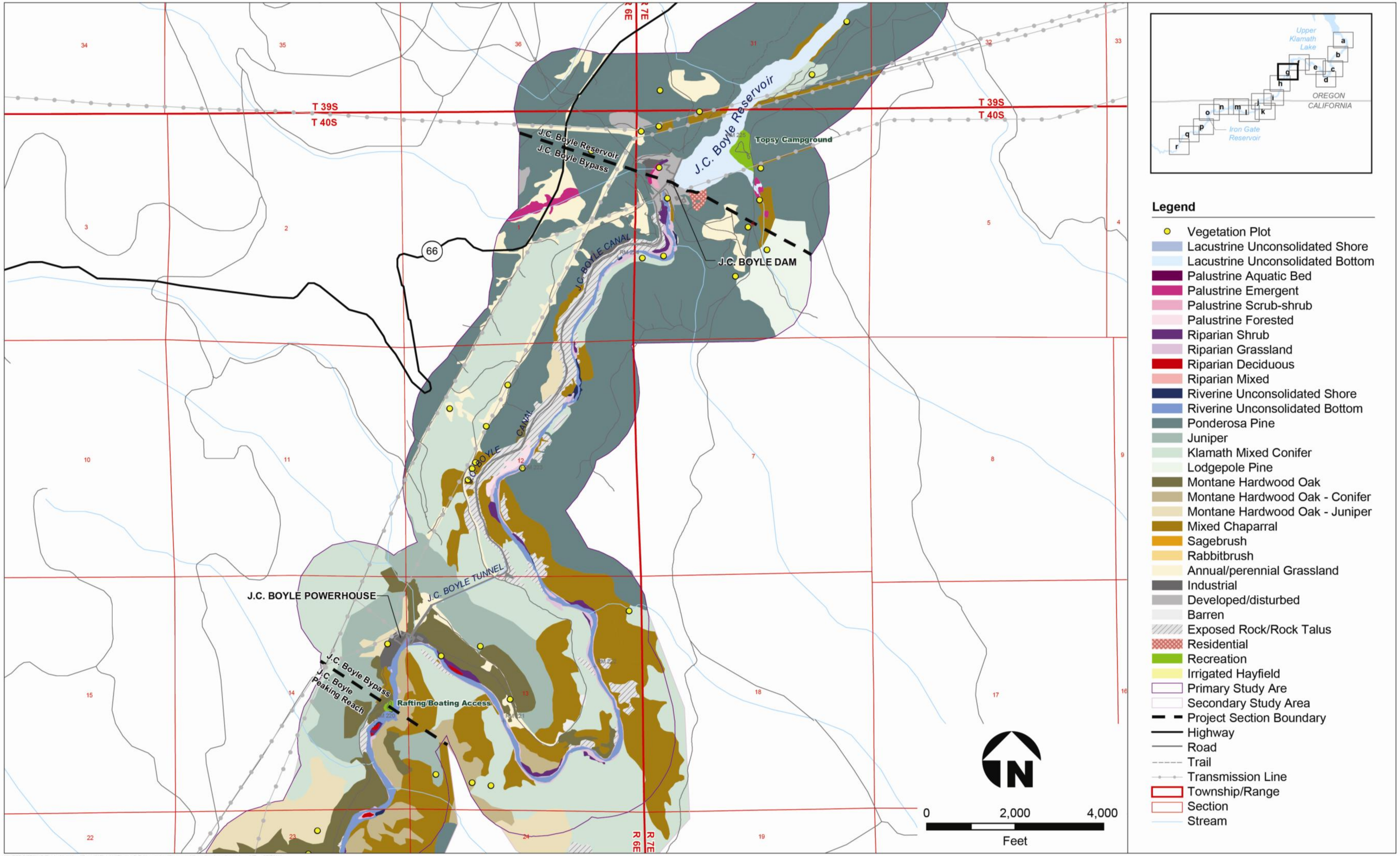
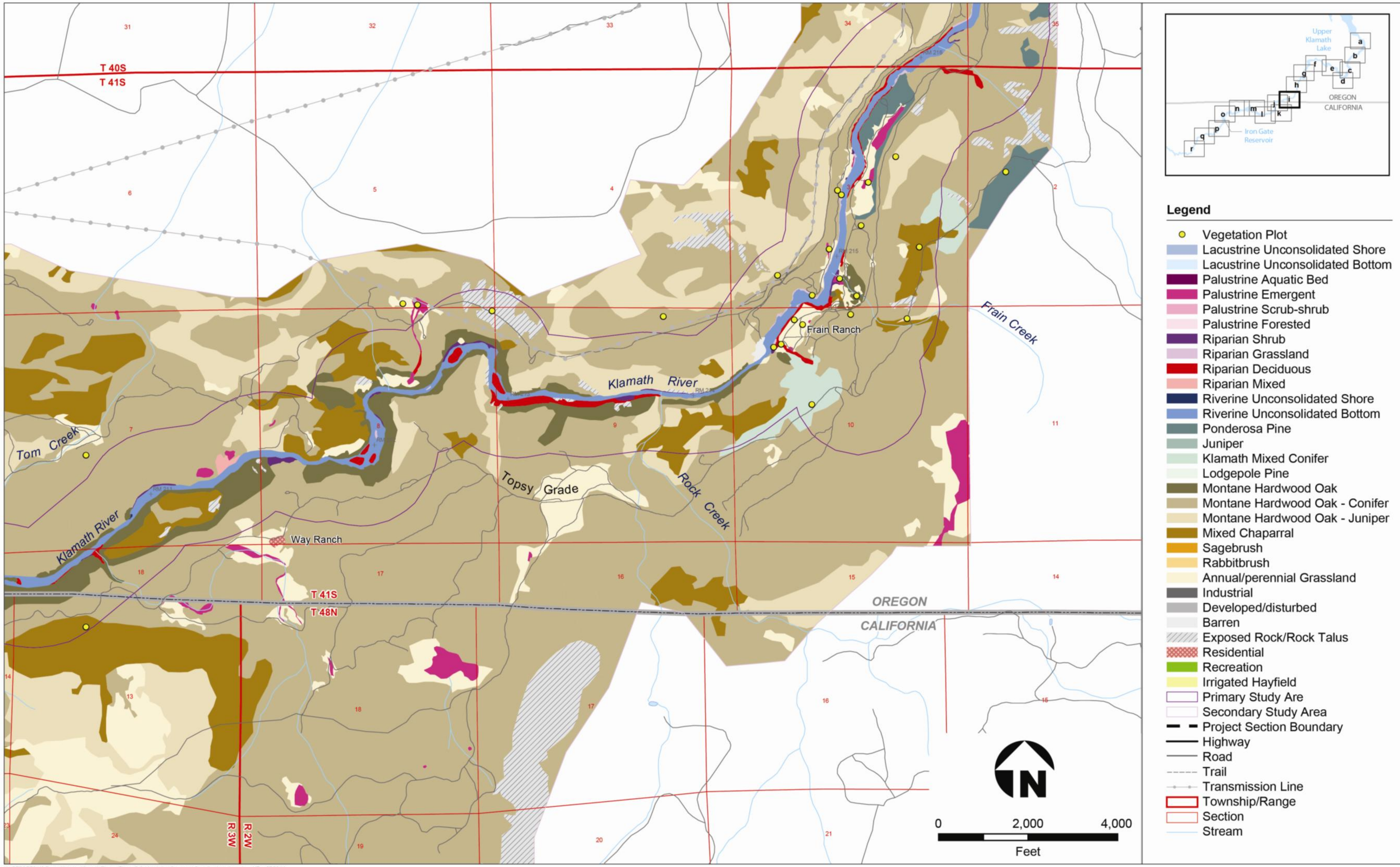


Figure G-7. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

Figure G-8. Vegetation Cover and Sampling Locations (PacifiCorp 2004)



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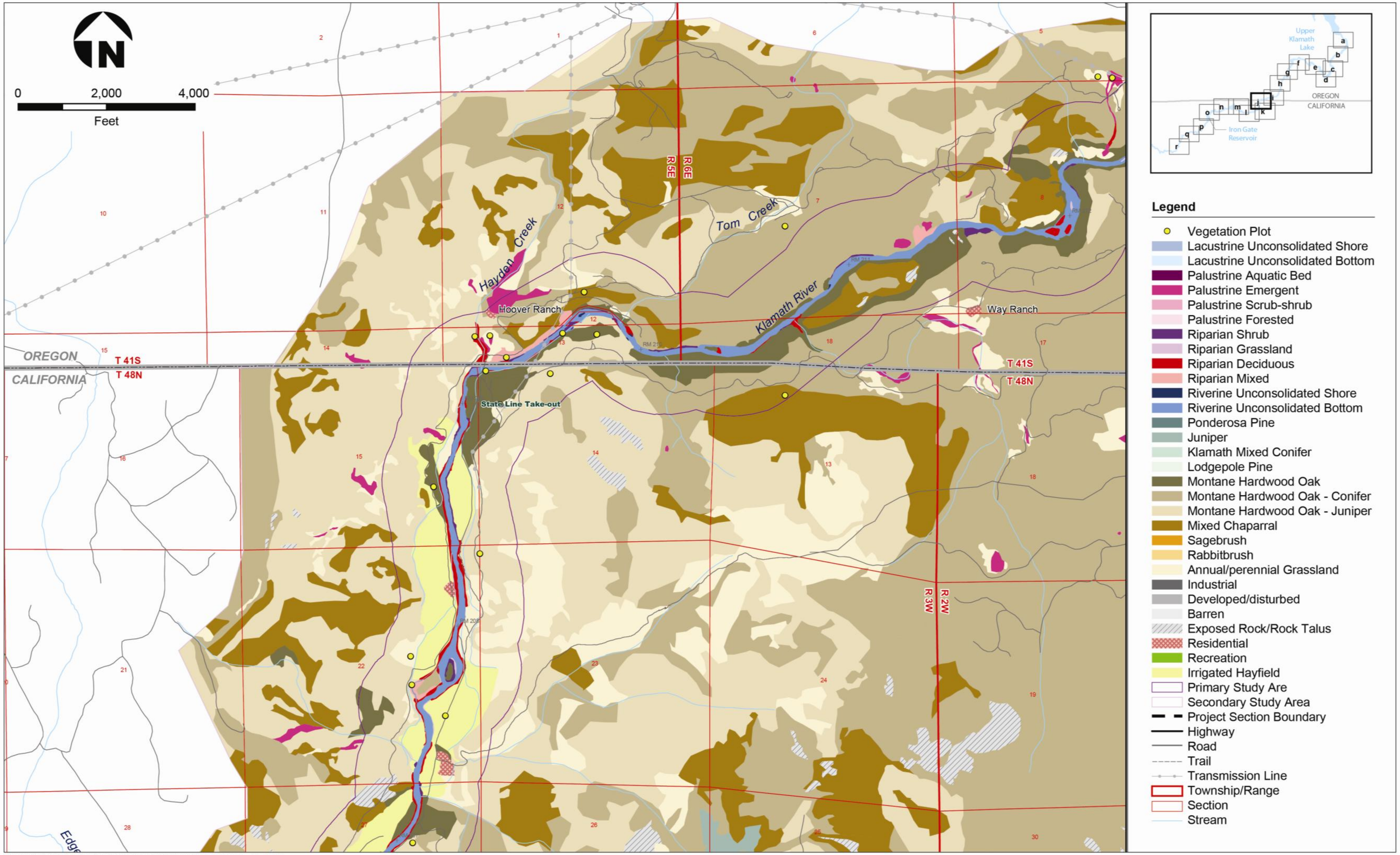


Figure G-10. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

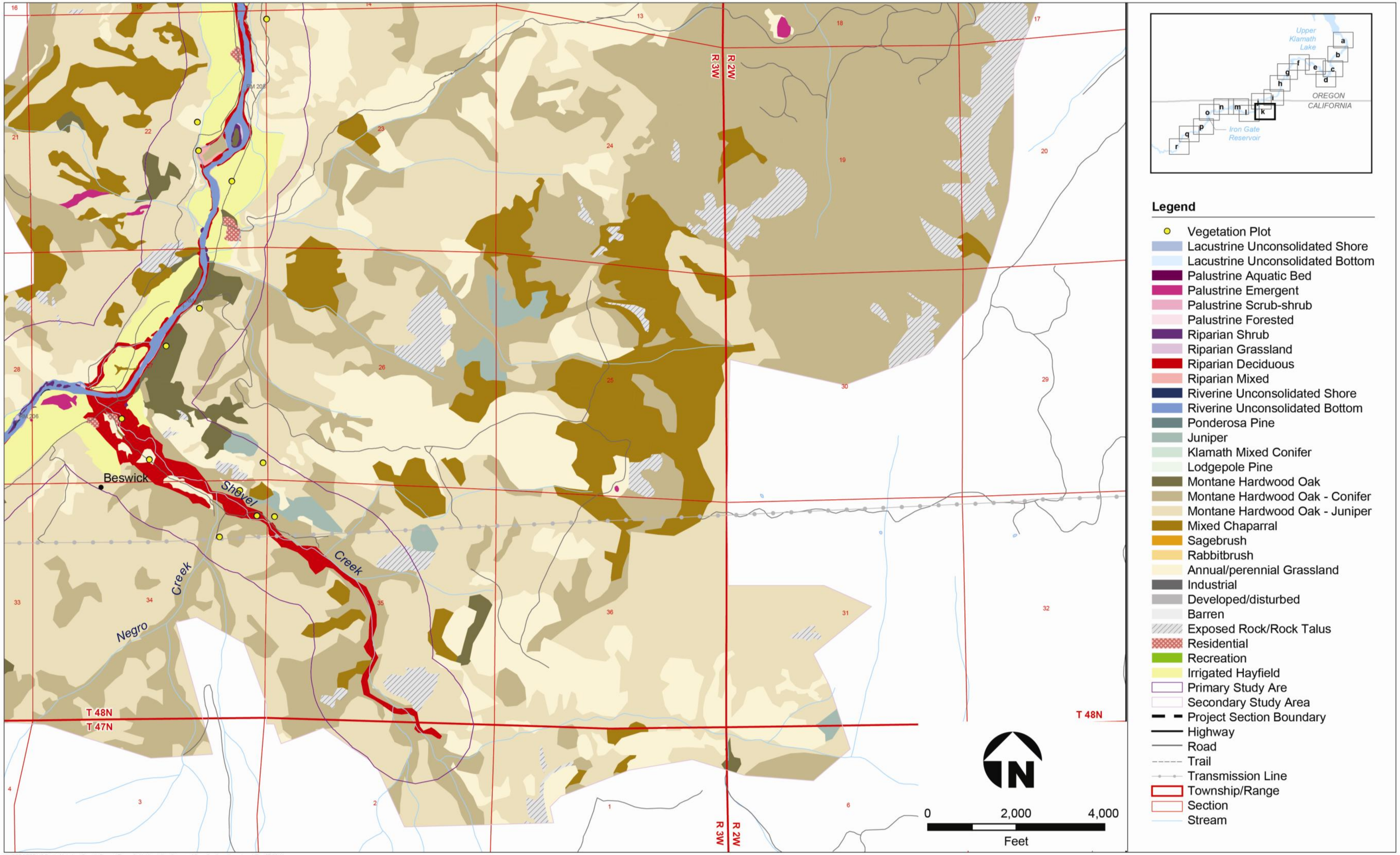


Figure G-11. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

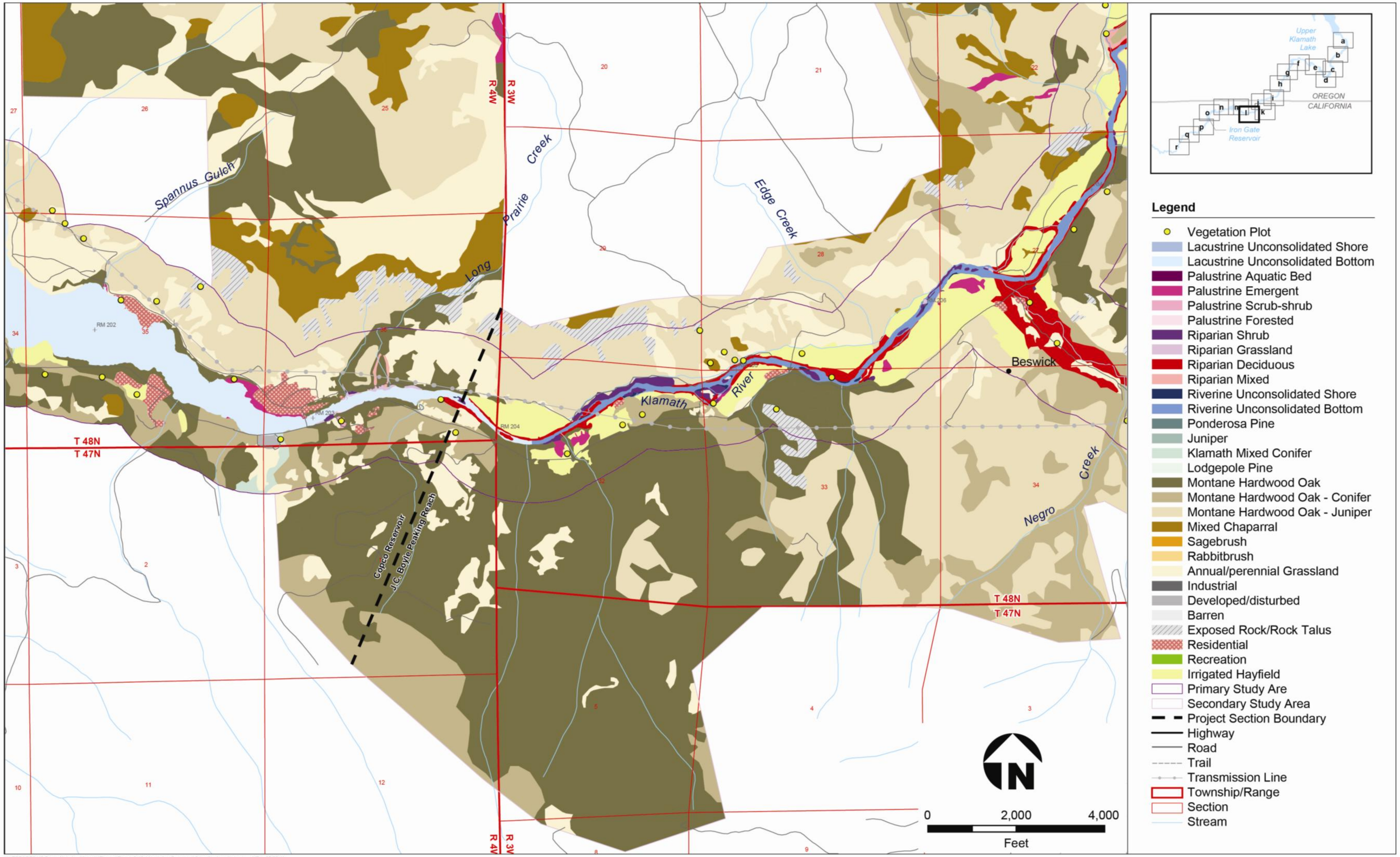


Figure G-12. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

Figure G-13. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

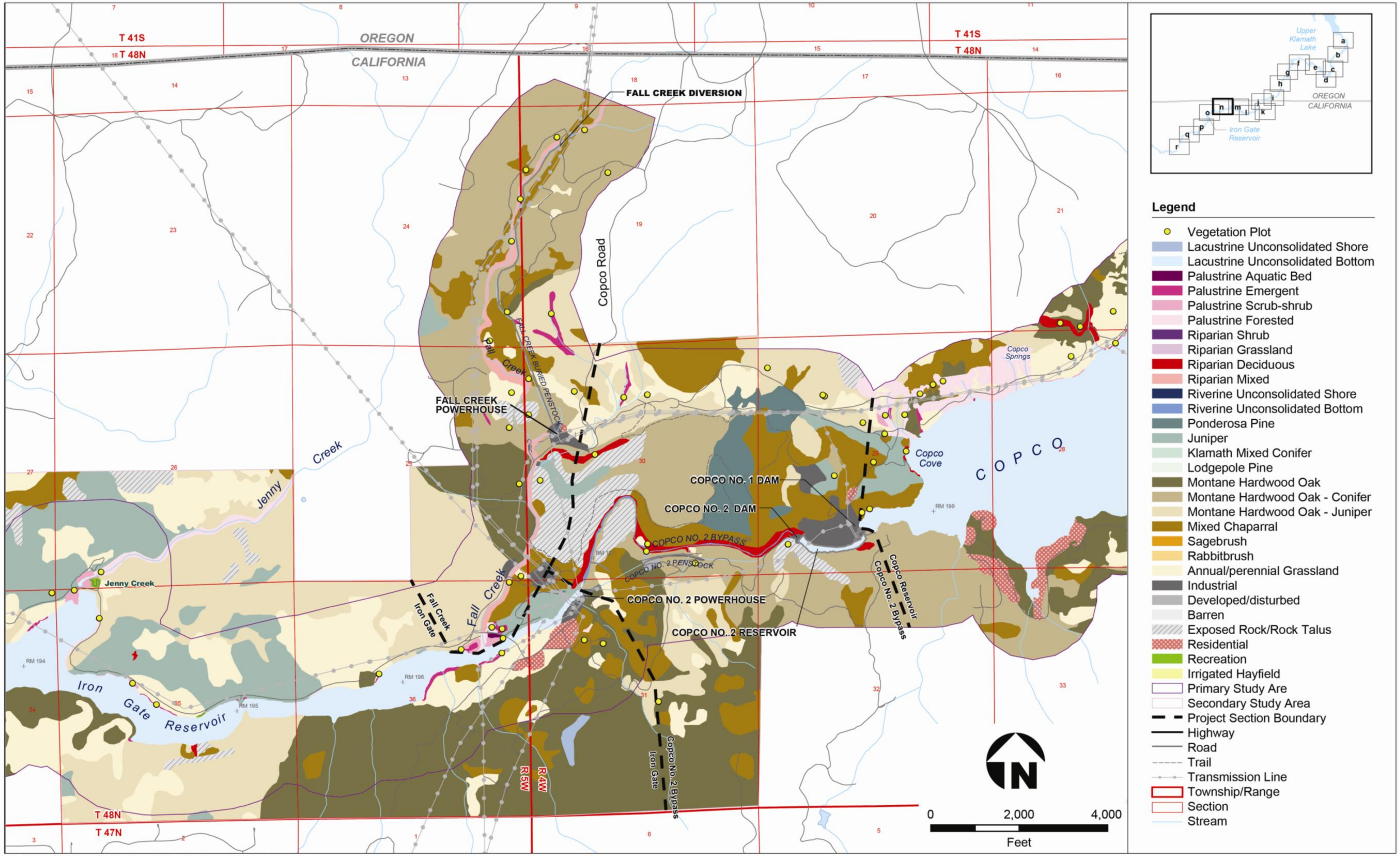
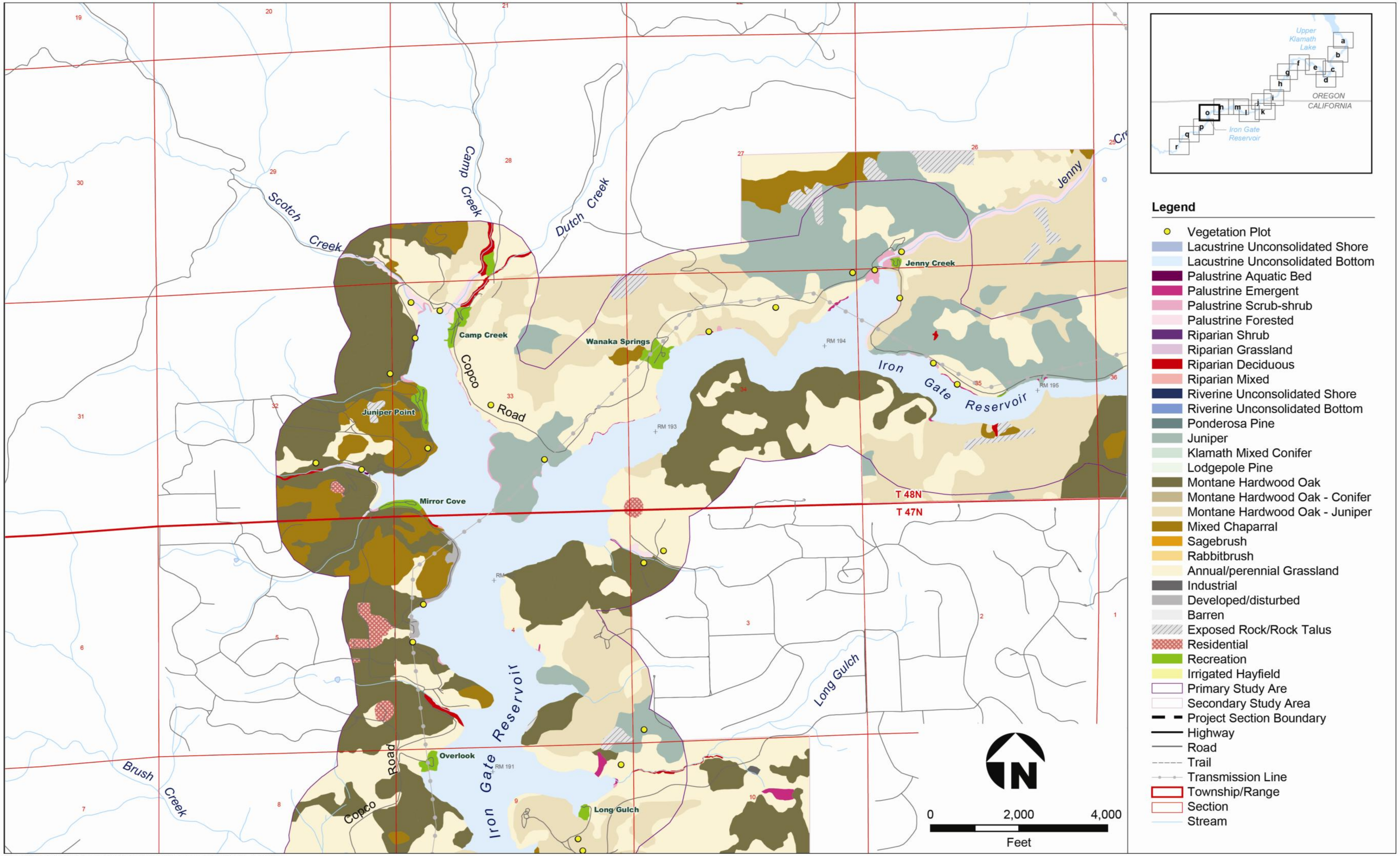


Figure G-14. Vegetation Cover and Sampling Locations (PacifiCorp 2004)



W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure G-15: Vegetation Cover and Sampling Locations.ai JJT 07/26/11

Figure G-15. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

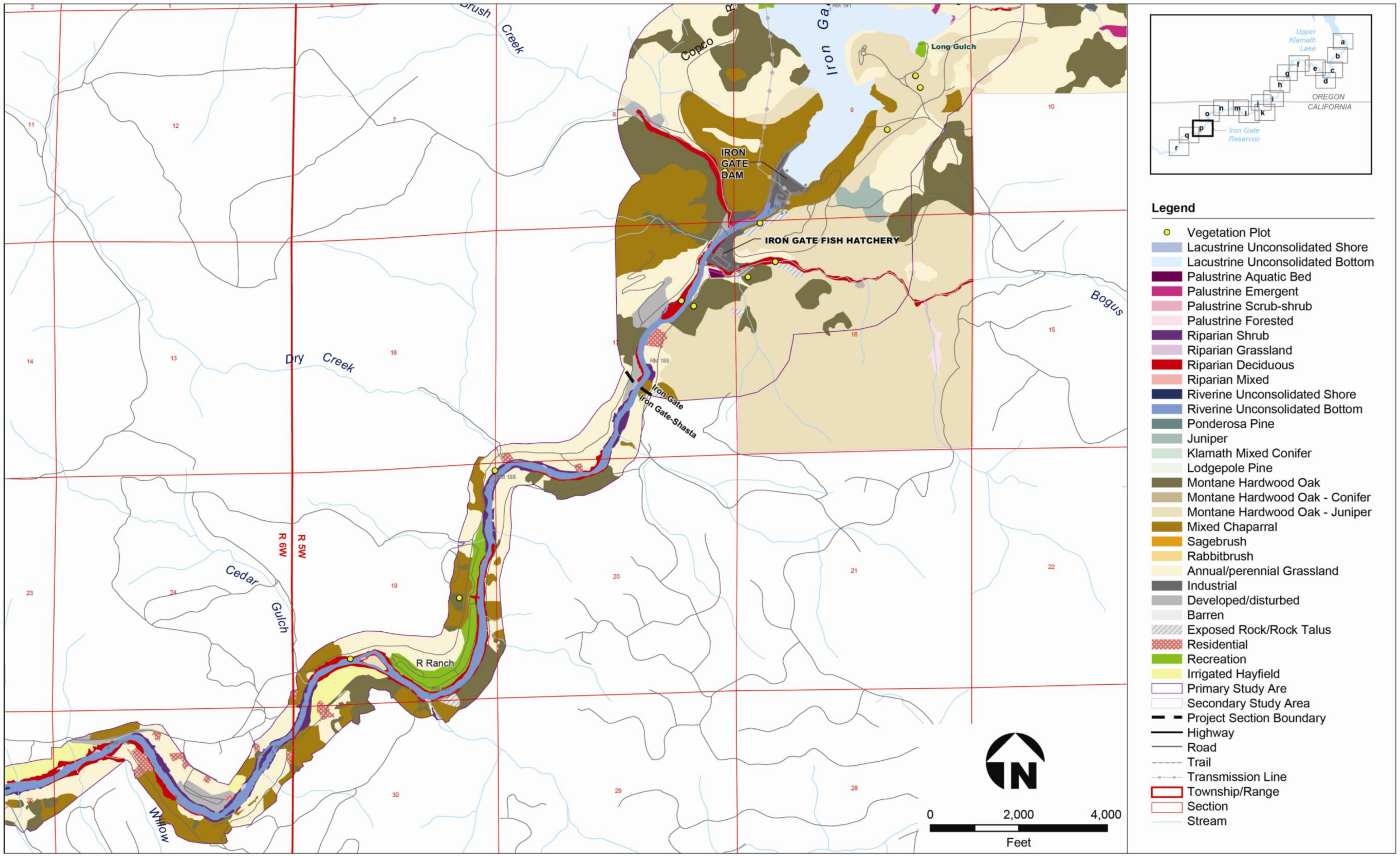


Figure G-16. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

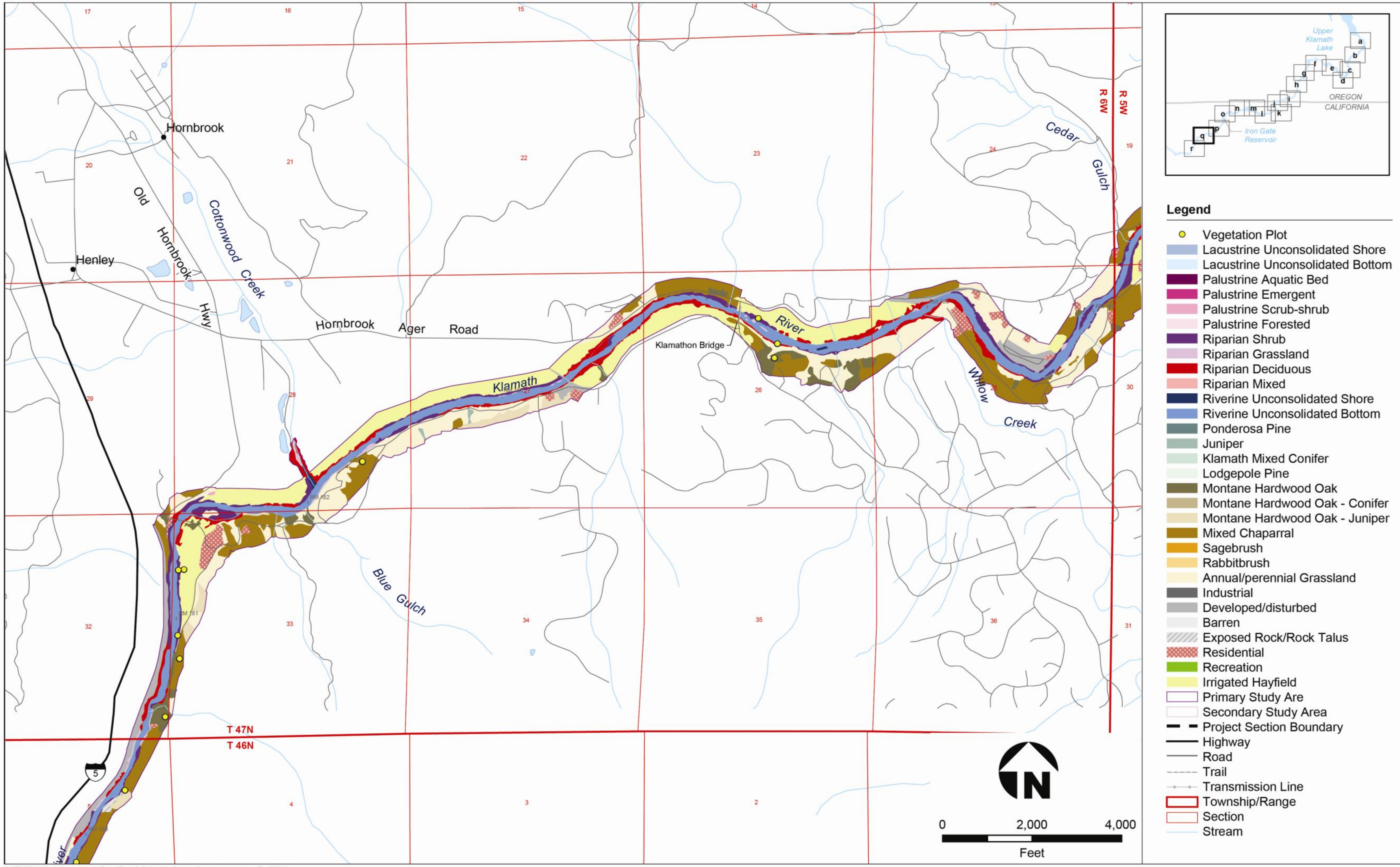


Figure G-17. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

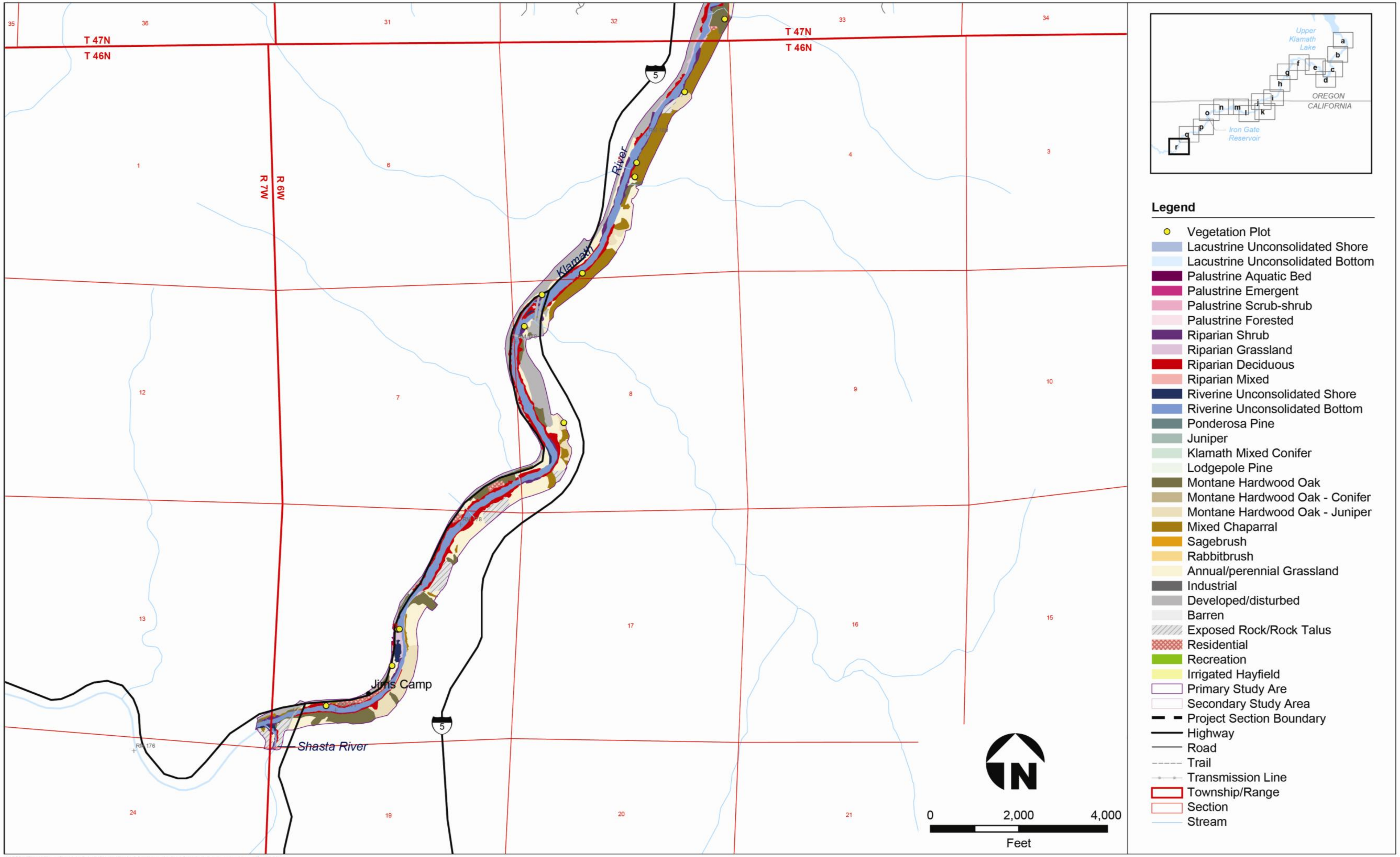


Figure G-18. Vegetation Cover and Sampling Locations (PacifiCorp 2004)

References

PacifiCorp. 2004. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). Portland, Oregon.

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Appendix H
Special-Status Species Surveys Conducted by PacifiCorp

This appendix provides information on special-status species based on surveys conducted by PacifiCorp and originally documented in:

> *Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February, 2004.*

The PacifiCorp study considered special-status species as plant and wildlife species with federal status through the U.S. Fish and Wildlife Service, Bureau of Land Management (BLM), U.S. Forest Service (USFS), or with state status in Oregon or California. The study also included federal threatened and endangered species (TES), federal candidate species, and federal species of concern, as well as state threatened and endangered species, state sensitive species, and state species of concern. The study included BLM and USFS Sensitive Species, Assessment Species, and Tracking Species, along with Survey and Manage species identified in the Northwest Forest Plan. In addition, species that were considered culturally sensitive for Indian Tribes and species of special interest or of economic significance were also addressed.

The list of special-status plant species for the PacifiCorp study was developed through agency consultation and included 65 vascular plants, three bryophytes, and ten lichens that could occur in the study area. In addition, a list of culturally sensitive species was provided by the Cultural Resources Working Group. The list of special-status wildlife species was developed in consultation with the Oregon Department of Fish and Wildlife, BLM, the Oregon Natural Heritage Program, now known as the Oregon Biodiversity Information Center, and the California Department of Fish and Game and includes 107 vertebrates (12 amphibians, 5 reptiles, 67 birds, and 23 mammals), 18 mollusks, and 4 insects.

PacifiCorp conducted focused surveys for special-status plants from May–July 2002 at representative cross sections of all the major habitats and topographic features in the study area, particularly in areas with a high potential for supporting the special-status plants. Several sites were revisited later in 2002 and in 2003. Special-status wildlife surveys were conducted in 2002 and 2003 in suitable habitat, identified on the basis of preliminary results of vegetation cover type mapping and in consultation with the resource agencies.

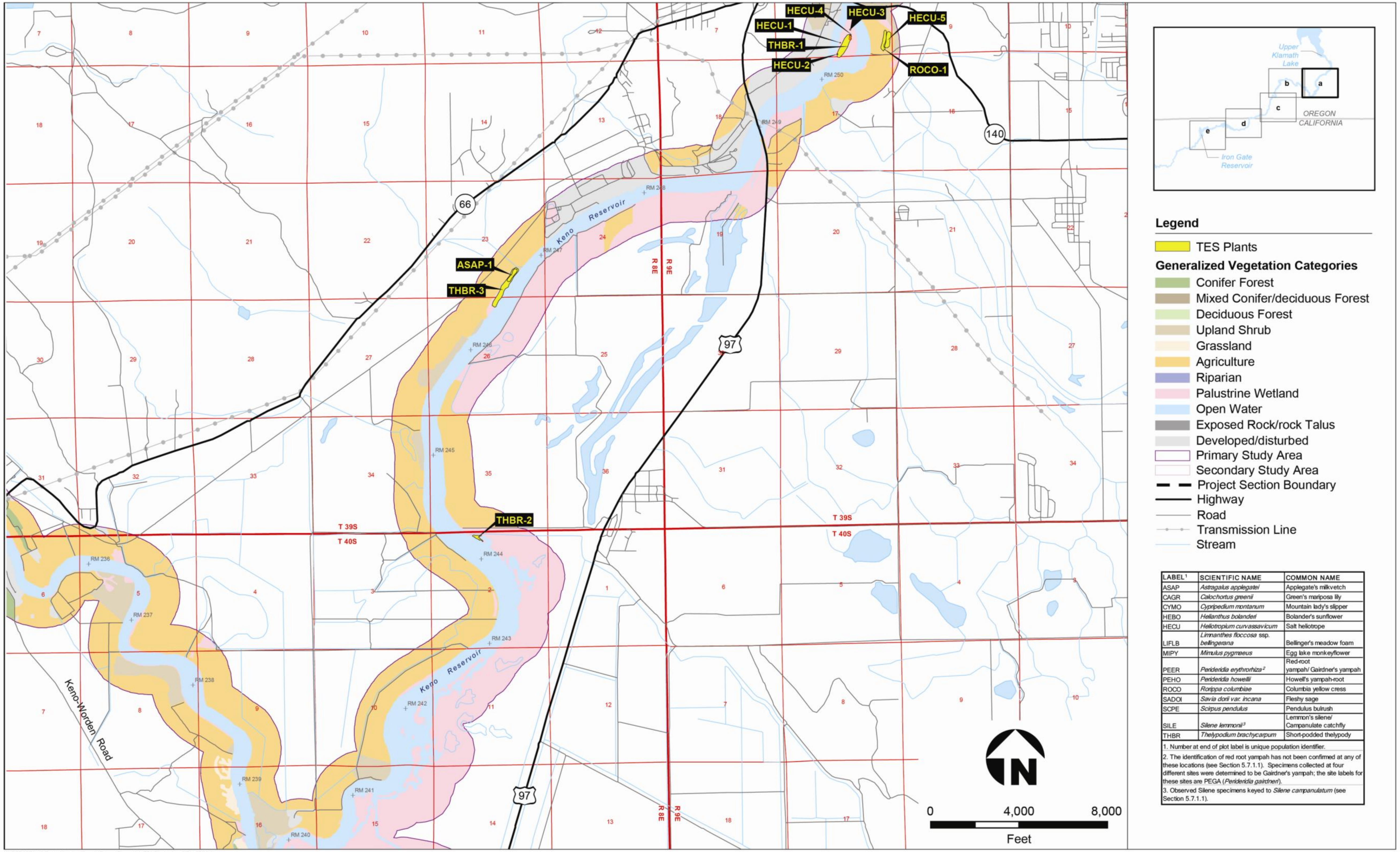
PacifiCorp conducted special-status amphibian surveys at ponds and wetlands, in selected tributary streams, and during a limited number of upland surveys in mesic coniferous habitat. Focused surveys were conducted for Oregon spotted frog and foothill yellow-legged frog. Survey locations were identified in consultation with state and federal resource agencies and local species experts and through review of aerial photos, maps, previous observations, and historical records. PacifiCorp conducted Oregon spotted frog surveys at four select wetland locations, and foothill yellow-legged frog surveys were conducted at ten sample sites.

Special-status reptile surveys were conducted by PacifiCorp in wildlife survey plots established in habitats throughout the study area, in select rock talus areas, and at potential snake hibernacula sites. PacifiCorp also conducted focused surveys for northwestern pond turtle along shorelines and within the river channel at reservoirs and along river reaches. Based on information gained from agency coordination, PacifiCorp conducted surveys for basking northwestern pond turtles and mapped suitable pond turtle nesting habitat.

PacifiCorp conducted special-status bird species using avian point counts and area searches in wildlife survey plots as well as at reservoirs. Focused surveys were conducted for northern spotted owl, northern goshawk, great gray owl, and bald eagle. In addition, five Rapid Ornithological Inventories were conducted in 2002 by ornithologists from the Klamath Bird Observatory to document avian use and occurrence in riparian habitat during the fall migration. The Rapid Ornithological Inventories included mist-netting and banding along with area searches and nocturnal call-and-response owl surveys conducted during an intensive 3-day survey period in several river reaches.

PacifiCorp conducted special-status mammal surveys in the winter of 2003 using track surveys and winter bait station field studies. PacifiCorp also conducted small mammal trapping and bat roost surveys in 2003 to further investigate the distribution of special-status mammals. Bat roost surveys were conducted once inside 24 PacifiCorp facility structures in June 2003 and under 14 bridges in the study area and entailed a visual inspection of all practically accessible areas within each facility by qualified biologists to identify bats to genus or species, if possible.

Figures H-1 through H-5 show vegetation surveys for TES plants along the Klamath River. Figures H-6 through H-8 show state and federal observations of TES wildlife along the Klamath River.



LABEL[1]	SCIENTIFIC NAME	COMMON NAME
ASAP	*Astragalus applegatei*	Applegate's milkvetch
CAGR	*Calochortus greenii*	Green's mariposa lily
CYMO	*Cypripedium montanum*	Mountain lady's slipper
HEBO	*Helianthus bolanderi*	Bolander's sunflower
HECU	*Heliotropium curvassavicum*	Salt heliotrope
LIFLB	*Limnanthes floccosa* ssp. *bellingerana*	Bellinger's meadow foam
MIPY	*Mimulus pygmaeus*	Egg lake monkeyflower
PEER	*Perideridia erythrorhiza*[2]	Red-root yampah/ Gairdner's yampah
PEHO	*Perideridia howellii*	Howell's yampah-root
ROCO	*Rorippa columbiae*	Columbia yellow cress
SADOI	*Savia dorii var. incana*	Fleshy sage
SCPE	*Scirpus pendulus*	Pendulus bulrush
SILE	*Silene lemmonii*[3]	Lemmon's silene/ Campanulate catchfly
THBR	*Thelypodium brachycarpum*	Short-podded thelypody

1. Number at end of plot label is unique population identifier.
2. The identification of red root yampah has not been confirmed at any of these locations (see Section 5.7.1.1). Specimens collected at four different sites were determined to be Gairdner's yampah; the site labels for these sites are PEGA (*Perideridia gairdneri*).
3. Observed Silene specimens keyed to *Silene campanulatum* (see Section 5.7.1.1).

W:\REPORTS\US Dept of Interior Klamath\Figures\Figure H-1 TES Plants.ai JJT 07/28/11

Figure H-1. TES Plants (PacifiCorp 2004)

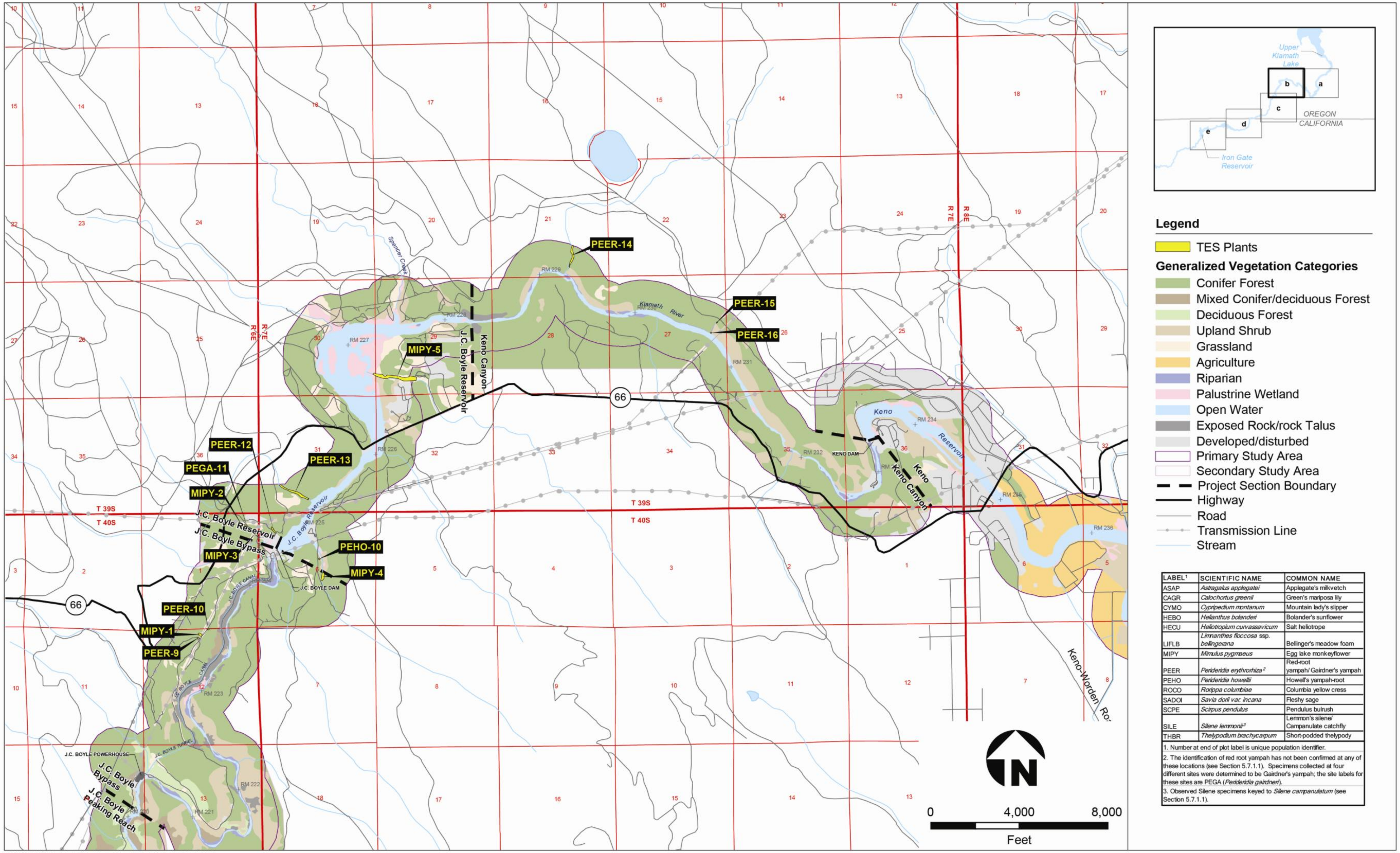


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Figure H-2. TES Plants (PacifiCorp 2004)

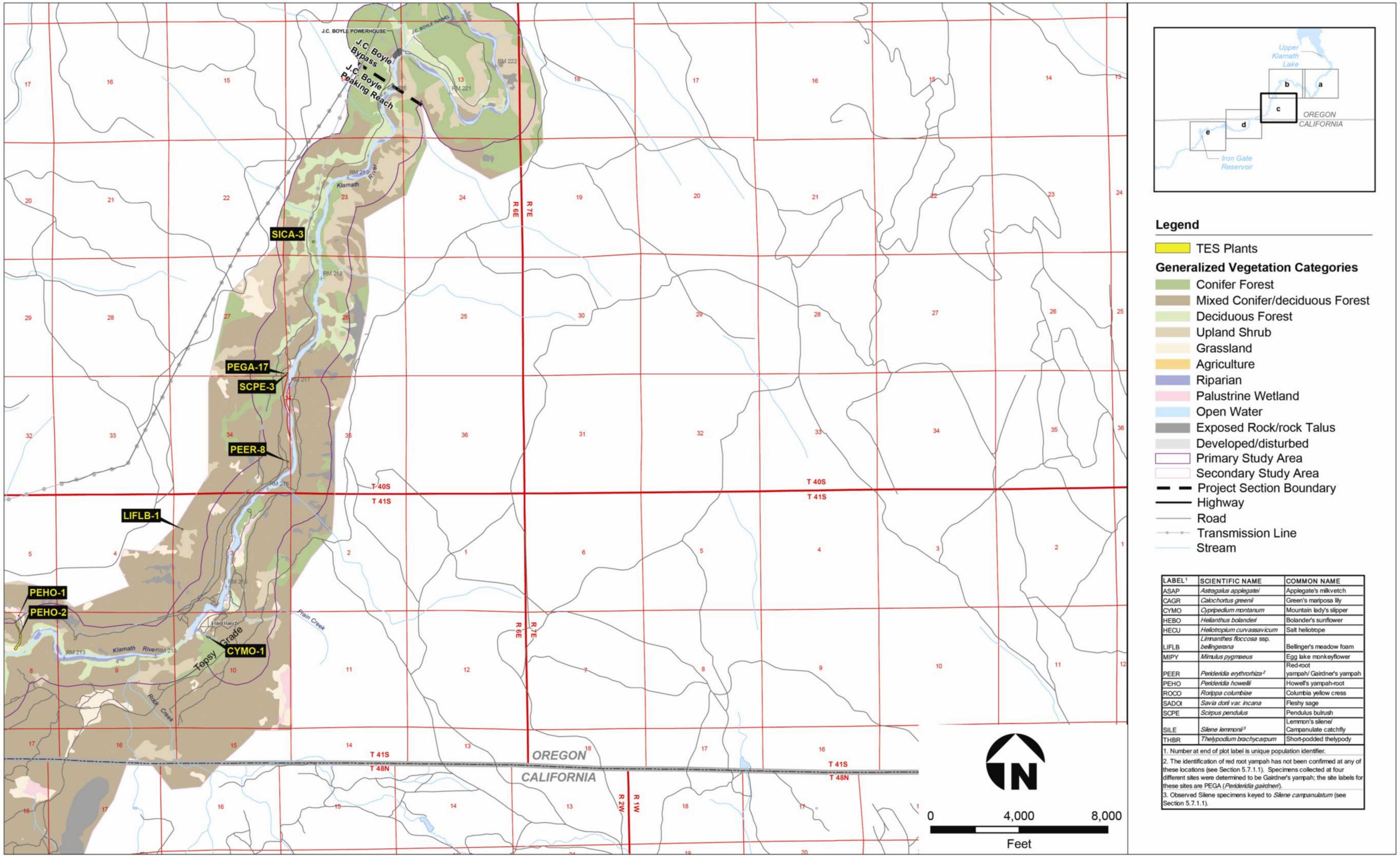

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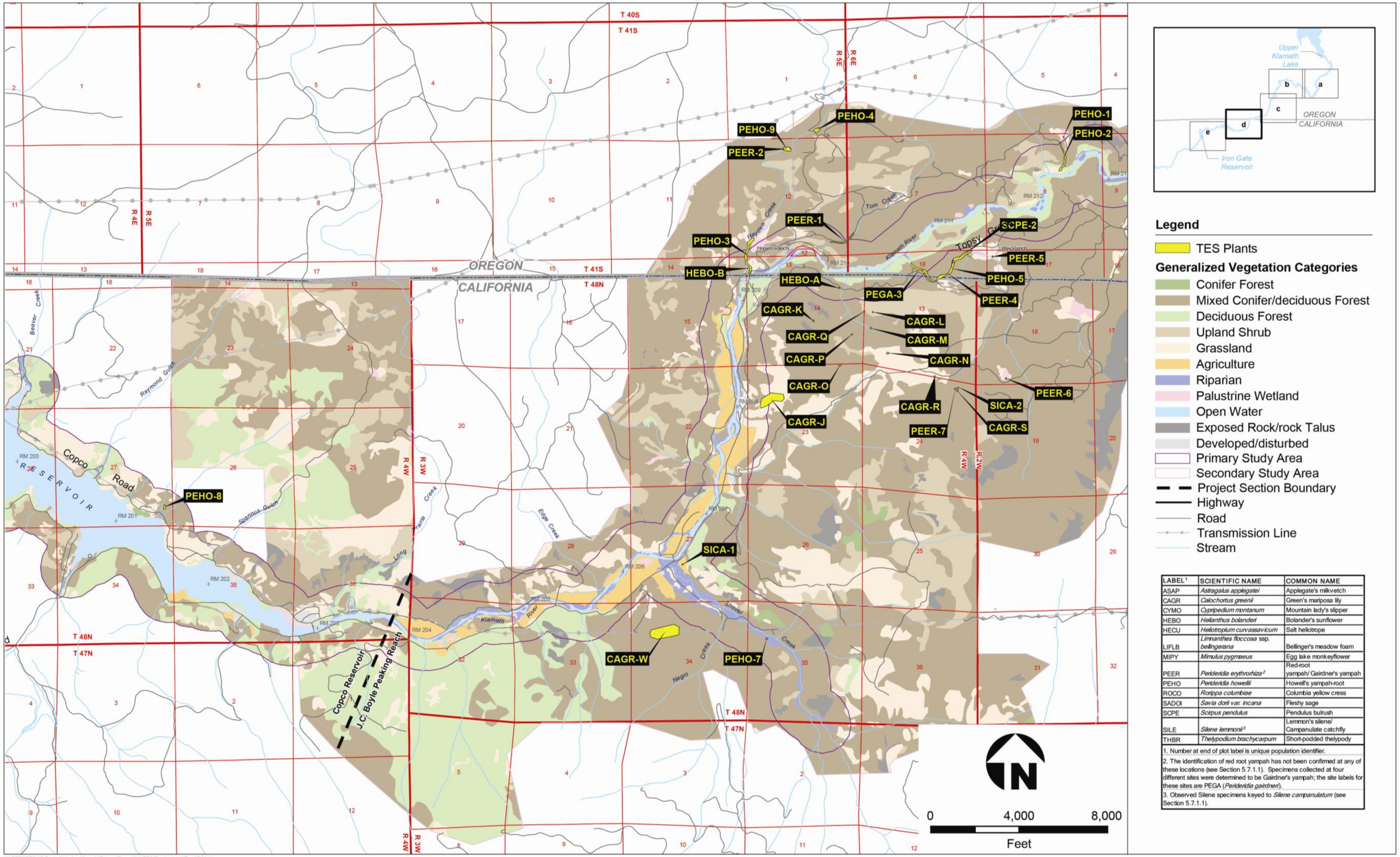
Figure H-3. TES Plants (PacifiCorp 2004)



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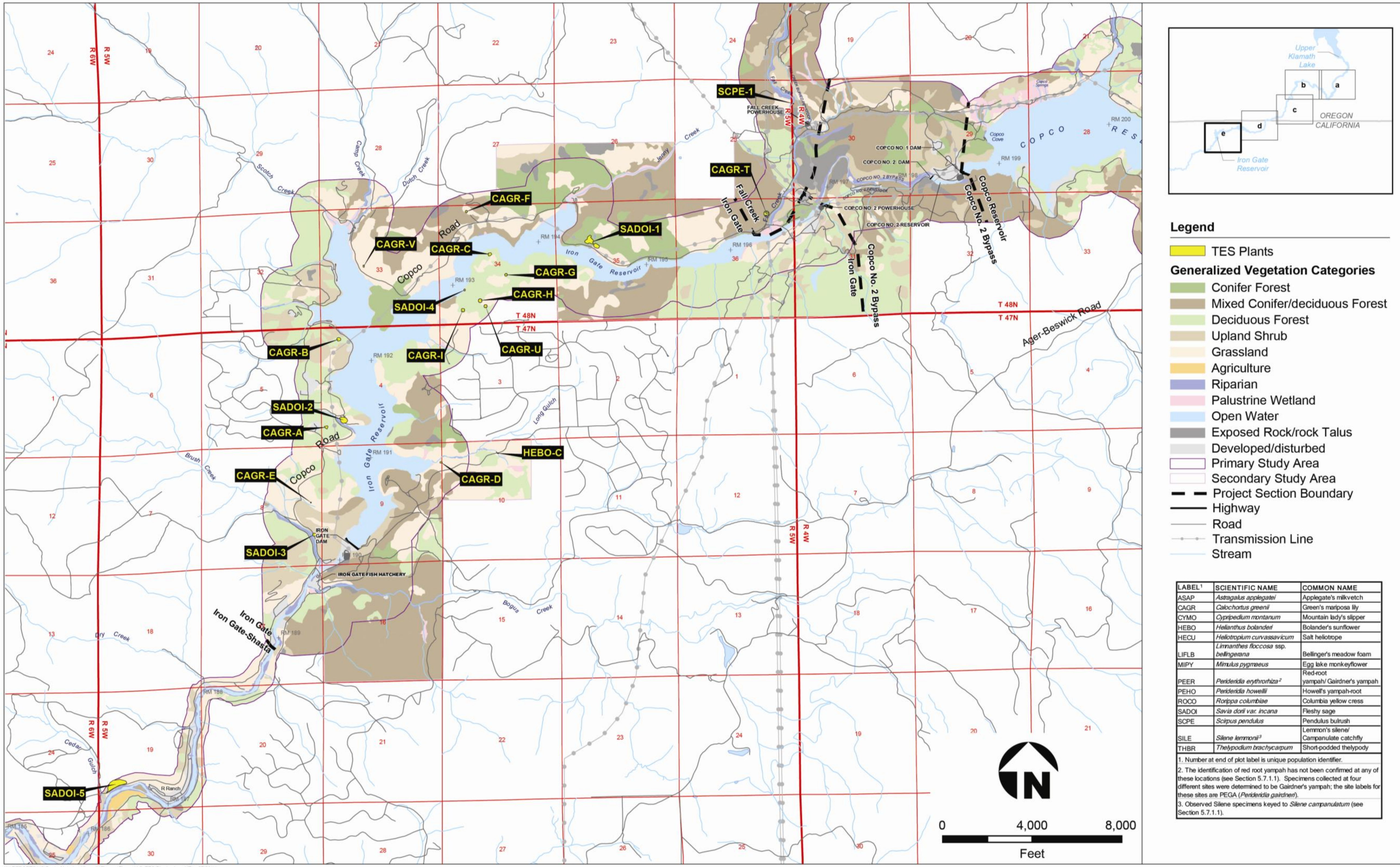

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Figure H-5. TES Plants (PacifiCorp 2004)

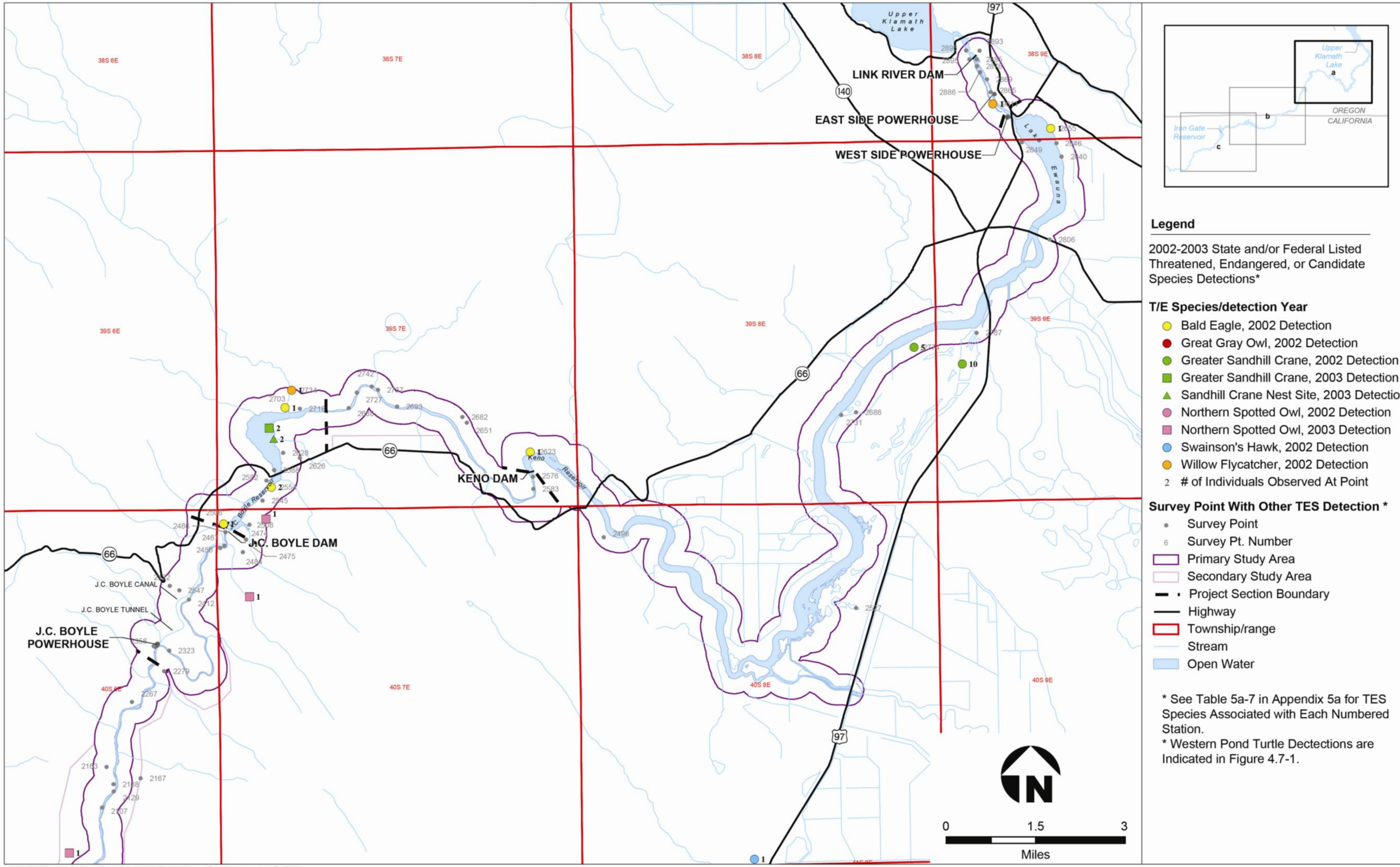

Figure H-6. 2002 TES Wildlife State and Federal Observations (PacifiCorp 2004)

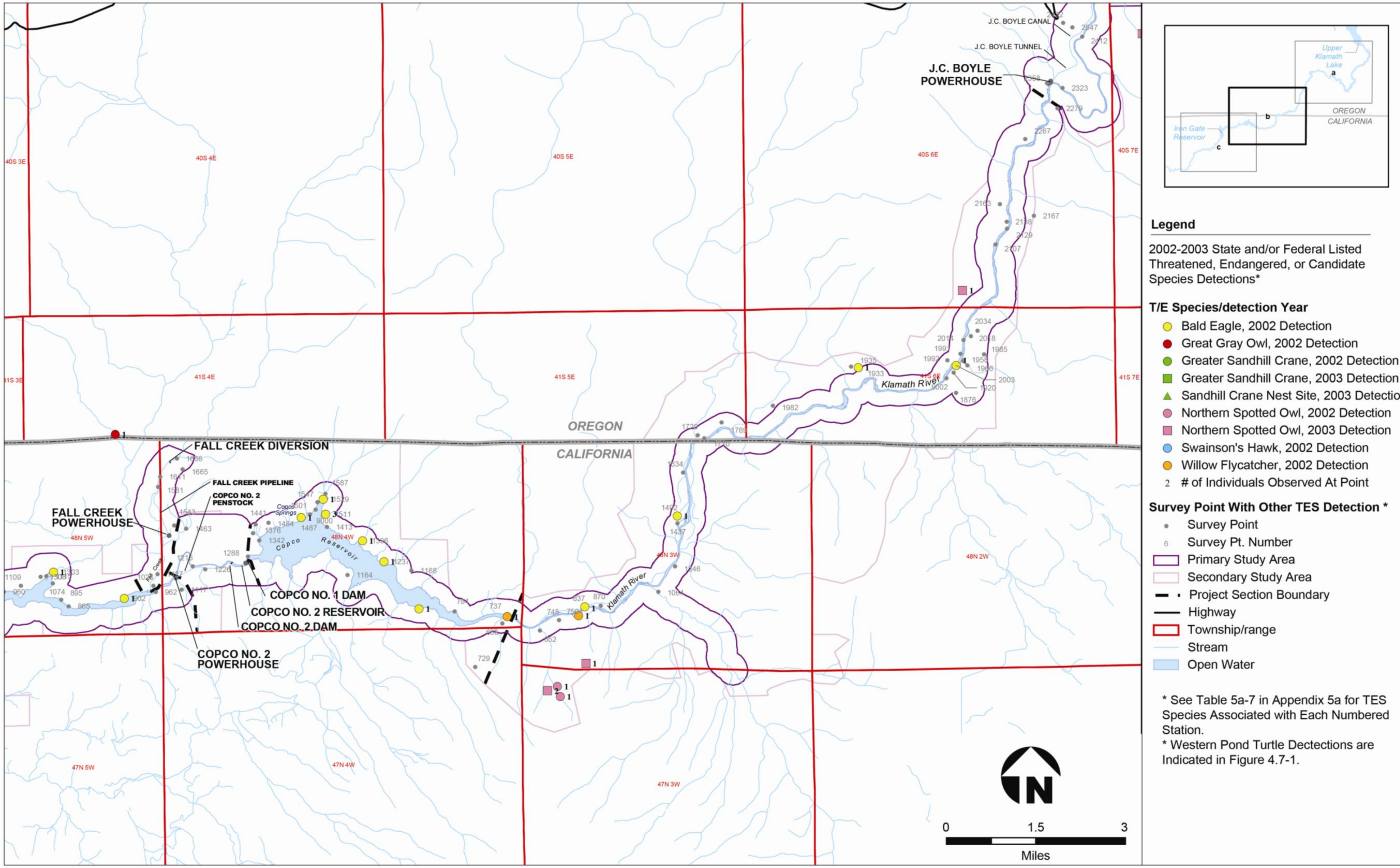

Figure H-7. 2002 TES Wildlife State and Federal Observations (PacifiCorp 2004)

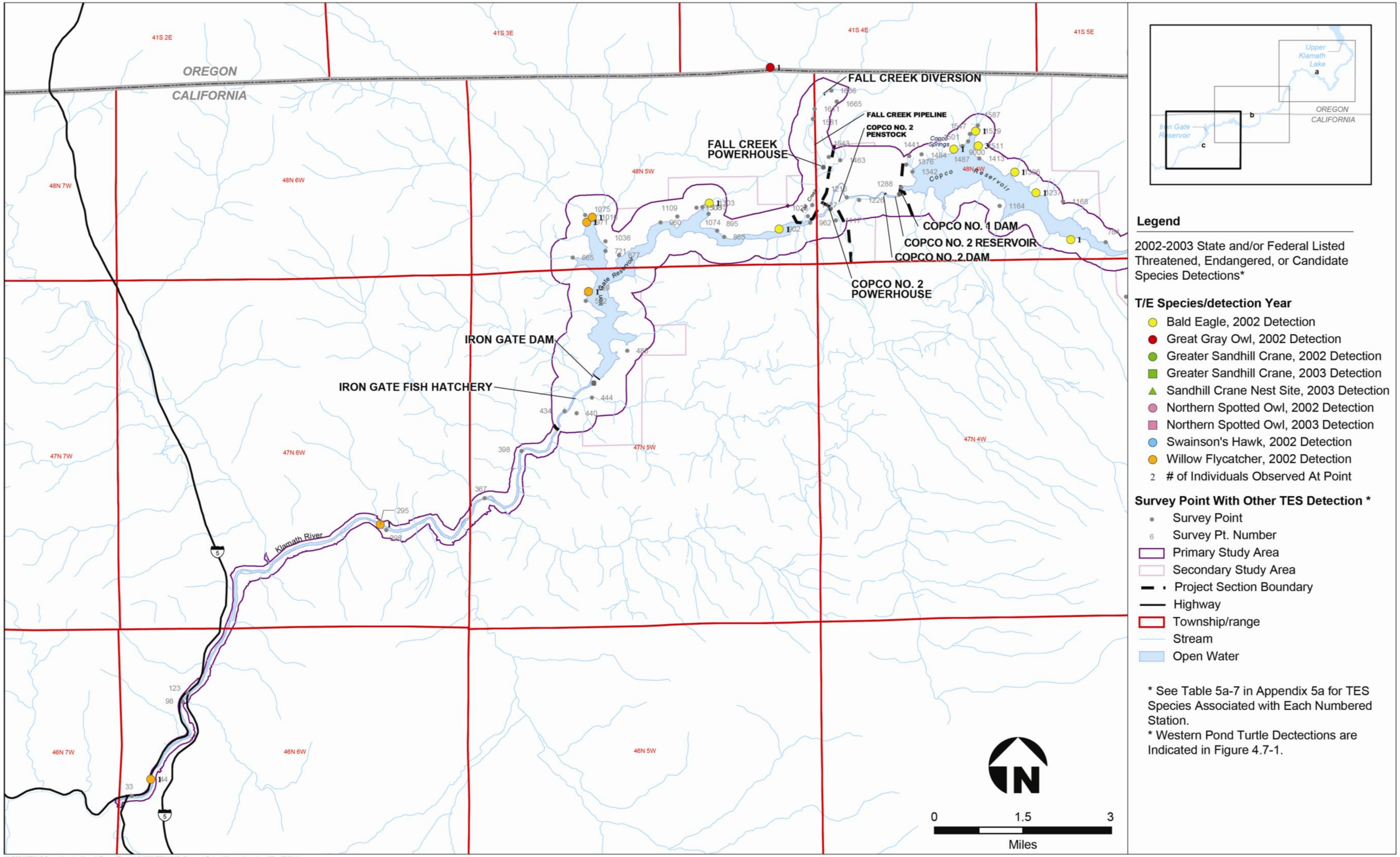

Figure H-8. 2002 TES Wildlife State and Federal Observations (PacifiCorp 2004)

H.1 References

PacifiCorp. 2004. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). Portland, Oregon.

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Appendix I
Special-Status Species Table

This appendix provides a comprehensive list of special-status species with some potential to occur in the project area (Table I-1). This list includes those species included on preliminary lists developed by PacifiCorp and originally documented in:

> *Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February, 2004.*

In addition, Table I-1 includes additional species listed by the Oregon Biodiversity Information Center (ORBIC) and the California Natural Diversity Database (CNDDB). The CNDDB search included the following U.S. Geologic Survey (USGS) 7.5-Minute Quadrangles in California:

- Secret Spring Mountain
- Copco
- Iron Gate Reservoir
- Hornbrook
- Hawkinsville
- Badger Mountain
- McKinley Mountain
- Horse Creek
- Hamburg
- Seiad Valley
- Slater Butte
- Happy Camp
- Clear Creak
- Ukonom Mountain
- Dillon Mountain
- Bark Shanty Gulch
- Somes Bar
- Orleans Mountain
- Orleans
- Fish Lake
- Weitchpec
- French Camp Ridge

- Johnsons
- Holter Ridge
- Ah Pah Ridge
- Klamath Glen
- Requa

Table I-1 includes 236 special-status species: 14 amphibians, 5 reptiles, 69 birds, 24 mammals, 112 plants, 3 bryophytes, and 9 lichens that have some potential to occur in the project area.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Amphibians				
California tiger salamander	*Ambystoma californiense*	FC, CSSC	Breeds in pools (mostly temporary). Adults may occur in annual grasslands and lowland riparian forests. Only two isolated populations are known to exist in Oregon; one is located in Klamath Falls, but neither occurs in the study area. In California, the species is offered protected status; range is generally restricted to areas south of Butte County (central California).	Not documented during PacifiCorp surveys.
Clouded salamander	*Aneides ferreus*	SU, ONHP List 3	Inhabits forests, including burned, clearcut, second growth, and rocky areas. Closely associated with decaying logs and stumps, particularly Douglas-fir. Inhabits burns and clearcuts until the decay process proceeds to the point where the wood becomes too dry. This species' range is restricted to the Coast Range and western Cascade Mountains of Oregon.	Not documented during PacifiCorp surveys.
Oregon slender salamander	*Batrachoseps wrighti*	FSC	Moist Douglas fir, maple, and red cedar woodlands; to 914 m. Range is north and west of study area.	Not documented during PacifiCorp surveys.
Scott Bar salamander	*Plethodon asupak*	CT	Rocky forested areas, especially thick moss-covered talus. Found in a very small area of the Siskiyou Mountains near the confluence of the Klamath and Scott Rivers, where the elevation is approximately 460 - 610 m.	Not documented during PacifiCorp surveys. Documented along tributaries of lower Klamath River (CNDDB 2010).
Del Norte salamander	*Plethodon elongatus*	FSC, S/M-D, SV, ONHP List 2, CSSC	Moist, rocky areas within forests. Can tolerate drier conditions and usually occurs in decaying logs and under litter on forest floor, especially in older conifer forests. Range is restricted to the coast range and barely extends into far western Siskiyou County.	Not documented during PacifiCorp surveys. Documented along tributaries of lower Klamath River (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Siskiyou Mountains salamander	*Plethodon stormi*	FSC, S/M-C, ONHP List 2, CT	Loose rock talus on north-facing slopes or in dense wooded areas. Also may be found under bark near talus. Range exists west of the study area but within the area of analysis.	Not documented during PacifiCorp surveys. Documented along tributaries of lower Klamath River (CNDDB 2010).
Southern torrent salamander	*Rhyacotriton variegatus*	FSC, SV, ONHP List 4, CSSC	Small streams and springs in Douglas-fir, mixed conifer, riparian, and upland deciduous forests. Range is west of, and including, the Coast Range Mountains from Mendocino County in California north through central Oregon, and barely extends into far western Siskiyou County.	Not documented during PacifiCorp surveys. Several occurrences along tributaries of lower Klamath River (CNDDB 2010).
Coastal (Pacific) tailed frog	*Ascaphus truei*	FSC, BLM, SV, ONHP List 2, CSSC	Requires fast, small, permanent streams with clear, cold water, cobble or boulder substrate, and little silt lakes. Tadpoles are generally found attached to the undersides of moss-free rocks in rapidly moving water and require 2 to 3 years to metamorphose; adults can also occur under rocks during the day. At night adults can be seen along stream edges and in adjacent forest stands up to 25 m from water. This species is reported to be restricted to areas north and west of the study area, and at higher elevations.	Not documented during PacifiCorp surveys. Several occurrences on tributaries to Klamath River outside study area (CNDDB 2010).
Western toad	*Bufo boreas*	BLM, SV, ONHP List 4	Breeds from February to early May in ponds, the edges of shallow lakes, and in slow-moving streams. Adults are common near marshes and small lakes but may also be found in dry forests, shrubby areas, and meadows.	Documented during PacifiCorp surveys along J.C. Boyle peaking reach, along the north shore of Iron Gate Reservoir, and along Klamath River near RM 185 (between the confluence of Bogus and Cottonwood Creeks). One occurrence near Frain Ranch, Klamath River Canyon (ORBIC 2010).
Northern red-legged frog	*Rana aurora aurora*	FSC, SU, ONHP List 2, CSSC	Breeds in cool, well-shaded ponds and wetlands; along the edges of lakes; or in slow streams. Adults can be found in moist coniferous or deciduous forests up to 300 m away from water and in forested wetlands. Range lies west of the study area but within the area of analysis.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
California red-legged frog	*Rana aurora draytonii*	FT, SC, ONHP List 1, CSSC	Found in dense, shrubby riparian vegetation associated with deep (0.7 m), still or slow-moving water. Vegetation that structurally seems to be most suitable is provided by arroyo willow; cattails and bulrushes also provide suitable habitat. Can occur in ephemeral or permanent streams or ponds, but populations probably cannot be maintained in ephemeral streams. Designated critical habitat is well south of the study area (50 CFR Part 17, March 13, 2001). Range lies west of the study area but within the area of analysis.	Not documented during PacifiCorp surveys. One occurrence near lower Klamath River (CNDDB 2010).
Foothill yellow-legged frog	*Rana boylii*	FSC, BLM, SV, ONHP List 2, CSSC	Inhabits permanent slow-moving streams with rocky bottoms in a variety of habitats.	Not documented during PacifiCorp surveys. Known to occur along J.C. Boyle bypass reach near J.C. Boyle Dam. Historical record below J.C. Boyle Reservoir (ORBIC 2010) and more recently along lower Klamath River (CNDDB 2010).
Cascades frog	*Rana cascadae*	FSC, BLM, ONHP List 2, CSSC	Wet meadows, bogs, moist forests, pond and stream edges. Breeds in bogs or ponds with cold springs or snow melt. Lays eggs in water depths < 20 cm. Range extends as isolated, noncontiguous patches along the Cascade mountain corridor to the Sierra Nevada Mountains in California. Species not known to occur in the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Oregon spotted frog	*Rana pretiosa*	FC, SC, ONHP List 1	Slow-moving and pond water in wetlands, ponds, and lake/river edges. Range occurs east of the study area, but is known to occur near Klamath Falls. Historically observed at the J.C. Boyle Reservoir. Current species' range includes the northern portion of the study area.	Not documented during PacifiCorp surveys.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Reptiles				
Northwestern pond turtle	*Actinemys marmorata marmorata*	FSC, BLM, SC, ONHP List 2, CSSC	Prefers quiet water in small lakes, marshes, and sluggish streams and rivers; requires basking sites.	Documented during PacifiCorp surveys at Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, along J.C. Boyle bypass reach, along J.C. Boyle peaking reach in California, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir and along Klamath River (ORBIC, CNDDB 2010).
Northern sagebrush lizard	*Sceloporus graciosus graciosus*	FSC, BLM, SV, ONHP List 4	Inhabits sagebrush, chaparral, juniper woodlands, and dry conifer forests.	Documented during PacifiCorp surveys in the rocky riparian shrub habitat of Keno reach, along J.C. Boyle peaking reach, near J.C. Boyle powerhouse intake canal, and near the edge of a forested wetland along Iron Gate Reservoir.
Sharptail snake	*Contia tenuis*	BLM	Inhabits moist sites in chaparral, conifer forests, and deciduous forests, but primarily occurs in oaks and other deciduous tree woodlands, particularly in the forest edges.	Known to occur along upper J.C. Boyle peaking reach west of Frain Ranch in Douglas-fir habitat but not detected by PacifiCorp during its surveys.
California mountain kingsnake	*Lampropeltis zonata*	FSC, BLM, SV, ONHP List 4	Inhabits thick vegetation along watercourses, farmland, chaparral, deciduous, and mixed-coniferous forests; specifically associated with moist river valleys and dense riparian vegetation.	Documented during PacifiCorp surveys along Copco Road and in close proximity to J.C. Boyle powerhouse intake canal. Also known to occur along J.C. Boyle peaking reach. Documented in Klamath River Canyon and at J.C. Boyle Dam (ORBIC 2010).
Common kingsnake	*Lampropeltis getula*	FSC, BLM, SV, ONHP List 4	Occurs in pine forests, oak woodlands, and chaparral in, under, or near rotting logs and usually near streams; associated with well-illuminated rocky riparian habitat with mixed deciduous and coniferous trees.	Documented during PacifiCorp surveys along J.C. Boyle peaking reach in oak/woodland and mixed conifer woodland and along Copco Road.
Birds				
Common loon	*Gavia immer*	FSC, CSSC	May over-winter on project reservoirs or occur in aquatic habitat associated with large bodies of water like the project reservoirs while migrating from sub-arctic freshwater breeding grounds to coastal and near-shore pelagic marine habitat along the Pacific coast.	Documented during PacifiCorp surveys at Iron Gate Reservoir.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Horned grebe	*Podiceps auritus*	BLM, SP, ONHP List 2	Reservoirs, ponds, and emergent wetlands throughout the study area represent suitable habitat. Nests are anchored to emergent vegetation. Occurs at Upper Klamath Lake.	Not documented during PacifiCorp surveys.
Red-necked grebe	*Podiceps grisegena*	SC, ONHP List 2	Reservoirs, ponds, and emergent wetlands throughout the study area represent suitable habitat. Nests in hardstem bulrush and forages in lakes, ponds and slow-moving rivers that are deeper than 5 feet. Known to breed on Upper Klamath Lake, Howard Prairie Reservoir, and Malheur National Wildlife Refuge. No breeding in California.	Not documented during PacifiCorp surveys.
American white pelican	*Pelecanus erythrorhynchos*	BLM, SV, ONHP List 2, CSSC	Nests at lakes and marshes and uses almost any lake outside of the breeding season; have a restricted range in southern Oregon and along the California border, where they are found to be associated with only a few large bodies of inland water.	Documented during PacifiCorp surveys on all project reservoirs, with the highest number occurring on Keno Impoundment, and along Link River, Keno reach, J.C. Boyle bypass reach, and on Klamath River between Iron Gate Dam and Shasta River.
Double-crested cormorant	*Phalacrocorax auritus*	Nesting colonies are afforded special protection by CDFG.	Colonial nester on coastal cliffs, offshore islands, and along lake margins.	Documented during PacifiCorp surveys at Keno and J.C. Boyle Dams. Documented nesting colonies near mouth of Klamath River (CNDDB 2010).
Western least bittern	*Ixobrychus exilis hesperis*	FSC, BLM, SP, ONHP List 2, CSSC	Inhabits emergent wetlands. Suitable habitat occurs upstream of J.C. Boyle Dam, primarily along upper Klamath Lake. Only six reports in Oregon since 1981. Known to have historically occurred in Upper Klamath Lake and downstream into the northern portion of the study area. Range includes portions of eastern Siskiyou County, east of the study area.	Not documented during PacifiCorp surveys.
Black-crowned night heron	*Nycticorax nycticorax*	FSC	Found in riparian habitats and in wetland sites.	Documented during PacifiCorp surveys primarily along Keno reach, but also along Link River, at Keno Impoundment, and along Klamath River from Iron Gate Dam to Shasta River. Communal roost used by night herons and other heron species located in a group of willow trees near the East Side powerhouse adjacent to Link River.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Snowy egret	*Egretta thula*	BLM, SV, ONHP List 2	Inhabits emergent wetlands associated with freshwater marshes and along the periphery of large water bodies. The northern limit of the species range includes southern Oregon.	Documented during PacifiCorp surveys near Link River Dam, at Keno Dam, and along Keno reach.
Great egret	*Casmerodius albius*	BLM	Nests in willows and other trees; forages in shallow water, wetlands, and fields. Range includes Klamath basin and eastern Siskiyou County. Known to occur in the study area.	Documented during PacifiCorps surveys at J.C. Boyle Reservoir and Keno Impoundment, Keno Canyon reach, J.C. Boyle bypass and peaking reaches, and Link River.
Great blue heron	*Ardea herodias*	Breeding colonies are afforded special-status protection by CDFG	Forages mostly in slow-moving or calm salt, fresh, or brackish water in a variety of habitats, including rocky shores, coastal lagoons, saltwater and freshwater marshes, mudflats, bays, estuaries, along the margins of rivers, lakes, and irrigation canals, and in flooded fields. Nesting colonies are typically found in groves of large trees, often in mixed colonies with other herons, egrets, and cormorants.	Documented during PacifiCorps surveys at all reservoirs and most study area reaches; rookery documented at Copco Reservoir. Several rookeries documented along the Klamath River (CNDDB 2010).
White-faced ibis	*Plegadis chihi*	FSC, BLM, ONHP List 4, CSSC	Breeds in freshwater marshes and lakes, and estuaries, and nests near the water on mats of vegetation and twigs; usually occurs in isolated con-specific flocks. Does not typically overwinter in Oregon but is a fairly common visitor in the Klamath Wildlife Area during the spring and summer.	Documented during PacifiCorp surveys along Link River and at Keno and J.C. Boyle Reservoirs.
Harlequin duck	*Histrionicus histrionicus*	FSC, SU, ONHP List 2, CSSC	Nests along remote low-gradient mountain streams. May occur along Klamath River from J.C. Boyle Dam to Copco Reservoir.	Not documented during PacifiCorp surveys.
Bufflehead	*Bucephala albeola*	BLM, SU, ONHP List 4	Typically breeds around isolated mountain lakes; nesting habitat includes mixed conifer forest and ponderosa pine forests with sparse to moderate tree canopy closure close to lakes and ponds. Nests in cavities, including artificial nest boxes. May be found in open water and riverine habitat throughout southern Oregon after the breeding season.	Documented during PacifiCorp surveys primarily from January until April along the Link River, at Keno, Copco, and Iron Gate Reservoirs.
Barrow's goldeneye	*Bucephala islandica*	SU, ONHP List 4, CSSC	Tends to breed along high-elevation mountain lakes and winter in coastal areas. Potential nesting habitat includes forests with sparse to moderate tree canopy closure next to rivers and reservoirs.	Documented during PacifiCorp surveys along Keno Impoundment, in an inundated drainage ditch off of Copco Reservoir, and on Iron Gate Reservoir.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Osprey	*Pandion haliaetus*	CSSC	Nests in all forested vegetation types with large trees near water, as well as on platforms erected in less optimal habitat.	A minimum of 16 active osprey nests, both artificial nesting platforms and natural sites, are located along the shores of the project reservoirs and river reaches. Documented during PacifiCorp surveys along the Keno reach, along the J.C. Boyle bypass reach, along the J.C. Boyle peaking reach, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Several occurrences along lower Klamath River (CNDDB 2010).
Northern harrier	*Circus cyaneus*	CSSC	Nests and forages in grasslands and emergent wetlands. Permanent residents in the project vicinity and common at the Klamath Wildlife Area.	Documented during PacifiCorp surveys in the low-lying marshland and agricultural fields east of Keno Impoundment and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Golden eagle	*Aquila chrysaetos*	CSSC, FP	Breeds in open mountain and hill habitats, nests on cliff ledges, and forages in grasslands and open conifer forests and woodlands with sparse to open tree canopy closure. Eagles use two to three nests during a lifetime.	Historical records exist of several golden eagle nests located on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. Documented during PacifiCorp surveys at J.C. Boyle powerhouse, along the lower section of J.C. Boyle peaking reach, along Copco and Iron Gate Reservoirs, and Copco bypass reach.
Bald eagle	*Haliaeetus leucocephalus*	FD, OT, ONHP List 4, CE	Nests in large conifers within several miles of water; forages in rivers and lakes for fish and waterfowl; requires large snags for perching and conifers for night roosts.	Documented during PacifiCorp surveys at all project reservoirs and in all project reaches throughout the project vicinity. Also documented on Upper Klamath River, on the Klamath River near OR-CA border (ORBIC 2010), and along lower Klamath River (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Cooper's hawk	*Accipiter cooperii*	CSSC	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak-juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure.	Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches, and along Klamath River from the Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Northern goshawk	*Accipiter gentilis*	FSC, BLM, CC, SC, ONHP List 4, CSSC	Inhabits forested communities with at least 60 percent canopy cover and trees greater than 6 inches in diameter, except oak woodland, oak-conifer woodland, and oak-juniper woodland; forages over large home ranges.	Documented during PacifiCorp surveys flying over J.C. Boyle peaking reach. Documented near tributaries of lower Klamath River (CNDDB 2010).
Sharp-skinned hawk	*Accipiter striatus*	CSSC	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure and tree diameters ranging from 6 to 24 inches.	Documented during PacifiCorp surveys in oak habitat along J.C. Boyle bypass and peaking reaches, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Ferruginous hawk	*Buteo regalis*	FSC, BLM, SC, ONHP List 2, CSSC	Nests on cliffs, isolated trees, or riparian forests for nesting and forages in open habitats with sparse to open tree closure (<40 percent). Range includes eastern Siskiyou County.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Swainson's hawk	*Buteo swainsoni*	FSC, BLM, SV, ONHP List 4, , CT	Dwells in open country and typically inhabits sagebrush, annual grassland, juniper woodland, montane hardwood oak-juniper, and riparian deciduous forest with sparse to open tree canopy closure. The species' range generally lies east of the project vicinity and includes the plains of the Great Basin in southeast Oregon and eastern northern California.	Documented during PacifiCorp surveys flying over agricultural fields southeast of Keno Impoundment. Not listed on CNDDB for project area (CNDDB 2010).
Merlin	*Falco columbarius*	BLM, ONHP List 2, CSSC	Uses a variety of forested and open habitats. Ranges throughout North America and travels great distances during migration from breeding grounds in northern Canada and Alaska to wintering habitat through the contiguous United States south to Central America.	Documented during PacifiCorp surveys at J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Prairie falcon	*Falco mexicanus*	CSSC	Uses cliffs for nesting and plateau grasslands for foraging.	Documented during PacifiCorp surveys near Keno Impoundment campground and boat ramp, above J.C. Boyle bypass reach, near Copco Reservoir, and flying over Klamath Wildlife Refuge. Several occurrences listed as sensitive (CNDDB 2010).
American peregrine falcon	*Falco peregrinus anatum*	FD, BLM, CC, OE, ONHP List 2, CE, FP	Breeds at suitable nest sites on cliffs and rocky outcroppings. Uses a variety of habitats, including open grassland areas, forest stands, and reservoirs throughout the project vicinity.	The project vicinity is located in a management area designated for peregrine falcon recovery. Known to occur along Keno Impoundment and the J.C. Boyle bypass reach but not documented during PacifiCorp surveys. Several occurrences listed as sensitive (CNDDB 2010).
Ruffed grouse	*Bonasa umbellus*	CSSC	Klamath mixed conifer forest conifer forest, ponderosa pine forest, riparian deciduous forest, and riparian shrub. Range overlaps portions of the study area.	Not documented during PacifiCorp surveys. Documented west of Klamath River near Ah Pah Creek and Trinity River outside of project area (CNDDB 2010).
Western greater sage grouse (southeast populations)	*Centrocercus urophasianus phaios*	FSC, SV, ONHP List 1, CSSC	Limited to areas with sagebrush coverage between 15 and 50 percent. Cover of grass and shrubs that are least 18 inches tall is important. Range occurs well east of the study area in both Oregon and California.	Not documented during PacifiCorp surveys.
Columbian sharp-tailed grouse	*Tympanuchus phasianellus columbianus*	FSC, ONHP List 1, CSSC	Inhabits grasslands, shrublands, woodland edges, and river canyons. No reported observations of sharp-tailed grouse in California since 1915. Unsuccessful reintroduction in northeastern Oregon.	Not documented during PacifiCorp surveys.
Mountain quail	*Oreortyx pictus*	FSC, BLM, SU, ONHP List 4	Inhabits open forests, chaparral, and juniper woodlands with dense undergrowth offering suitable refuge; breeds in higher elevation areas; migrates on foot up to 40 miles to lower elevation winter grounds.	Documented during PacifiCorp surveys at J.C. Boyle reservoir, along the J.C. Boyle bypass reach and peaking reaches, along Fall Creek, and along Klamath River from the Iron Gate Dam to Shasta River.
Yellow rail	*Coturnicops noveboracensis*	FSC, BLM, SC, ONHP List 2, CSSC	Freshwater marshes and wet meadows with sedges. Less than 100 breed in northern Klamath County, Oregon, which includes a small isolated population that supposedly nests along Upper Klamath Lake.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Greater sandhill crane	*Grus canadensis tabida*	FSC, BLM, SV, ONHP List 4, CT, FP	Nests in marshes and wet meadows, and occasionally in pastures and irrigated hayfields. A primary requirement for suitable nesting habitat is the presence of surrounding water or undisturbed habitat.	Documented during PacifiCorp surveys east of Keno Impoundment and along J.C. Boyle reservoir. PacifiCorp located an active nest with two eggs in it in the emergent wetland bordering J.C. Boyle Reservoir. Several occurrences in the Lower Klamath Lake NWR (CNDDB 2010).
Western snowy plover (Interior populations)	*Charadrius alexandrines nivosus*	FT, OT, ONHP List 1, CSSC	Lake and river shorelines. Study area habitats are upstream of J.C. Boyle Dam. One breeding colony is known to occur in southern Klamath County.	Not documented during PacifiCorp surveys.
Long-billed curlew	*Numenius americanus*	FSC, CC, ONHP List 4, CSSC	Annual grasslands, perennial grasslands, emergent wetlands, pastures, and irrigated hayfields. Long-billed curlews are known to breed along the margins of Upper Klamath Lake; suitable breeding habitat for the species exists throughout the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Upland sandpiper	*Bartramia longicauda*	FSC, SC, ONHP List 2	Sagebrush, annual grassland, perennial grassland, and emergent wetlands. Study area habitats are upstream of J.C. Boyle Dam. No breeding sites occur in Klamath County or Siskiyou County.	Not documented during PacifiCorp surveys.
Caspian tern	*Sterna caspia*	CC	Nests in tightly packed colonies on undisturbed islands, levees, and shores along inland water bodies during the summer breeding season. Forages over water.	Documented during PacifiCorp surveys on all project reservoirs as well as along Link River, Keno and J.C. Boyle bypass reaches, and along the Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Forster's tern	*Sterna forsteri*	BLM, ONHP List 4	Breeds at lakes and marshes and on mud or sand flats near water; forages over water.	Documented during PacifiCorp surveys along Link River, along Keno and J.C. Boyle bypass and peaking reaches, and at all project reservoirs. Not listed on CNDDB for project area (CNDDB 2010).
Black tern	*Chlidonias niger*	FSC, BLM, ONHP List 4, CSSC	Nests in emergent vegetation along the shoreline periphery of freshwater lakes, wetlands, and marshes along rivers and ponds; forages in wet meadows, pastures, agricultural fields, and water.	Documented during PacifiCorp surveys at Keno and J.C. Boyle Reservoirs. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	FC, CC, SC, ONHP List 2, CE	Riparian deciduous forest with dense tree canopy closure (>59 percent) and shrub canopy (>59 percent). Suitable breeding habitat does exist for the species in the study area and the species may occur in the Project vicinity.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Short-eared owl	*Asio flamneus*	FSC, CSSC	Uses annual grassland, perennial grassland, irrigated hayfield, pasture, emergent wetland cover types. Most suitable habitat in the study area is upstream of J.C. Boyle Dam. Breeding is known to occur throughout Klamath County; suitable breeding and foraging habitat for the species exists throughout the Project vicinity.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Long-eared owl	*Asio otus*	CSSC	Uses riparian deciduous forest, conifer forests, mixed forests. Year-round resident throughout southeast Oregon and in the Project region.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Western burrowing owl	*Athene cunicularia hypugaea*	FSC, SC, ONHP List 2, CSSC	Montane hardwood oak woodland and montane hardwood oak-juniper with sparse tree canopy closure (<25 percent), annual grassland, perennial grassland, pasture cover types, as well as the sparse tree canopy closure (<25 percent) stage of ponderosa pine forest and juniper cover types. Range is mostly in eastern Oregon, and includes some areas of northern Klamath County.	Not documented during PacifiCorp surveys.
Flammulated owl	*Otus flammeolus*	BLM, CC, SC, ONHP List 4	Nests in abandoned woodpecker nest cavities in open forests with a ponderosa pine component.	Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches.
Great gray owl	*Strix nebulosa*	BLM, S/M-C, SV, ONHP List 4, CE	Inhabits mixed conifer, ponderosa pine, and riparian mixed forest stands with trees greater than 11 inches in diameter providing at least 60 percent canopy cover within at least 984 feet of a natural or manmade opening greater than 10 acres. Breeds in tree cavities, typically located near suitable open grassland foraging habitat.	Documented during PacifiCorp surveys east of Fall Creek near Jenny Creek. Not listed on CNDDB for project area (CNDDB 2010).
Northern Spotted Owl	*Strix occidentalis caurina*	FT, OT, ONHP List 1	Inhabits ponderosa pine forest and mixed conifer forest with trees greater than 11 inches in diameter. Prefers old-growth forests with multi-layered tree canopies. Critical habitat occurs within the project area along portions of the lower Klamath River.	Documented during PacifiCorp surveys near J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Several occurrences within the project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Vaux's swift	*Chaetura vauxi*	CSSC	Found in mixed conifer, ponderosa pine, lodgepole pine, riparian deciduous, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper forests with trees greater than 11 inches in diameter.	Documented during PacifiCorp surveys at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle bypass and peaking reaches, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Black swift	*Cypseloides niger*	SP, ONHP List 2, CSSC	Suitable nesting habitat is limited to cliffs near water courses. Breeding sites are widely distributed in Oregon and California; none known in Klamath or northern Siskiyou Counties.	Not documented during PacifiCorp surveys. Documented along Klamath River near Orleans (CNDDB 2010).
Pilelated woodpecker	*Drycopus pileatus*	BLM, SV ONHP List 4	Occurs in all forest and woodland cover types with moderate to dense tree canopy closure. Requires large snags 25 inches or more in diameter for excavating suitable nest cavities.	Documented during PacifiCorp surveys along Keno reach, at J.C. Boyle Reservoir, along J.C. Boyle bypass and peaking reaches, and along Fall Creek.
Acorn woodpecker	*Melanerpes formicivorus*	FSC, BLM, ONHP List 4	Nests in cavities located in snags of deciduous tree species, particularly oak snags at least 17 inches in diameter.	Several nesting colonies documented during PacifiCorp surveys in oak, oak-juniper, and oak/conifer habitats, primarily at Copco Reservoir. Also documented during PacifiCorp surveys at J.C. Boyle and Iron Gate Reservoirs, along J.C. Boyle peaking reach, along Copco bypass reach, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River.
Lewis' woodpecker	*Melanerpes lewis*	FSC, BLM, CC, SC, ONHP List 2	Associated with oak woodlands and mixed oak conifer habitat, but also can be found in a variety of open forest stands including ponderosa pine and cottonwood-dominated riparian areas.	Documented during PacifiCorp surveys in upland habitats along J.C. Boyle peaking reach, in riparian habitats at Iron Gate Reservoir, and along Klamath River from Iron Gate Dam to Shasta River. Documented in Klamath River Canyon (ORBIC 2010).
White-headed woodpecker	*Picoides albolarvatus*	FSC, BLM, CC, SC, ONHP List 2	Nests in cavities typically located in ponderosa pine at least 18 inches in diameter. Occurs in lodgepole pine, ponderosa pine, and Klamath mixed conifer forests with trees greater than 11 inches in diameter.	Documented during PacifiCorp surveys along J.C. Boyle bypass reach. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Black-backed woodpecker	*Picoides arcticus*	BLM, SC, ONHP List 4	Lodgepole pine, ponderosa pine forest, and Klamath mixed conifer forest forests with trees greater than 11 inches dbh. Range is within the study area.	Not documented during PacifiCorp surveys.
Three-toed woodpecker	*Picoides tridactylus*	BLM, SC, ONHP List 4	Lodgepole pine, ponderosa pine forest, and Klamath mixed conifer forests upstream of Keno Dam. Elevation may be too low for this species to occur in the study area. Range occurs along Cascades, well north of the study area.	Not documented during PacifiCorp surveys.
Williamson's sapsucker	*Sphyrapiicus thyroideus*	BLM, SU	Associated with higher-elevation coniferous forest types including ponderosa pine, lodgepole pine, and Douglas-fir.	Known to occur in the general project vicinity but not documented during PacifiCorp surveys.
Olive-sided flycatcher	*Contopus cooperi*	FSC, BLM, CC, SV, ONHP List 4	Typically found in coniferous forests with tall trees providing suitable perch sites.	Documented during PacifiCorp surveys along Link River, at Keno, J.C. Boyle and Iron Gate Reservoirs, and along Keno and J.C. Boyle peaking reaches. Not listed on CNDDB for project area (CNDDB 2010).
Willow flycatcher	*Empidonax traillii*	FSC, BLM, CC, SV, ONHP List 4, CE	Associated with dense riparian willow thickets.	Documented during PacifiCorp surveys in some of the more dense willow patches along Link River, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle peaking reach, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir at Jenny Creek (CNDDB 2010).
Black phoebe	*Sayornis nigricans*	BLM	Nests on cliffs or rock outcrops near water. Forage in riparian areas with thick vegetation and some nearby vertical surface. The Klamath study area exists along the northern limit of the species range.	Documented during PacifiCorp surveys along the Iron Gate-Shasta reach.
Loggerhead shrike	*Lanius ludovicianus*	ONHP List 4, CSSC	Riparian and wetland forests, as well as Klamath mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper that have sparse to moderate tree canopy closure (<60 percent). Range includes the Klamath basin.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Pinyon jay	*Gymnorhinus cyanocephalus*	BLM	Juniper and ponderosa pine woodlands. Range includes eastern Klamath and Siskiyou Counties east of the study area.	Not documented during PacifiCorp surveys.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Purple martin	*Progne subis*	FSC, BLM, SC, ONHP List 2, CSSC	Riparian and wetland forests, as well as Klamath mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper with sparse to moderate tree canopy closure (<60 percent). Range is patchy and may include portions of the study area.	Documented during PacifiCorp surveys above the upper falls at Fall Creek.
Bank swallow	*Riparia riparia*	FSC, BLM, SU, ONHP List 4, CT	Suitable habitat most often associated with roadcuts or riparian embankments. Range includes Klamath basin. No colonies are known to exist in the Project vicinity, but the species may occur in the study area during the breeding season and migration.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Black-capped chickadee	*Parus atricapillus*	CSSC	Nests in a variety of woodland habitats wherever suitable, small nest cavities can be found.	Documented during PacifiCorp surveys along Link River and at Copco and Iron Gate Reservoirs.
Pygmy nuthatch	*Sitta pygmea*	BLM, SV	Typically found in ponderosa pine forests with less than 70 percent canopy closure.	Documented during PacifiCorp surveys at Keno and J.C. Boyle Reservoirs.
Blue-gray gnatcatcher	*Polioptila caerulea*	BLM	Mixed chaparral, montane hardwood oak woodland, montane hardwood oak-juniper. Range overlaps the study area. The species is specifically known to breed in the chaparral of the Klamath basin.	Documented during PacifiCorp surveys at Iron Gate reservoir.
Western bluebird	*Sialia mexicana*	BLM, SV, ONHP List 4	Found in a variety of open habitats; may be limited by the availability of suitable nesting cavities. Nests in open clearings adjacent to woodlands or in human-made structures providing suitable nest sites.	Documented during PacifiCorp surveys along Copco bypass reach, along Fall Creek, and at Iron Gate Reservoir.
Yellow warbler	*Dendroica petechia*	CSSC	Found in riparian deciduous forest, riparian shrub, scrub-shrub wetland, and forested wetland. Breeds in riparian habitat throughout North America and winters south from Mexico through South America.	Documented during PacifiCorp surveys throughout the project vicinity at all project reservoirs and in all project reaches. Not listed on CNDDB for project area (CNDDB 2010).
Yellow-breasted chat	*Icteria virens*	FSC, BLM, ONHP List 4, CSSC	Found in the brushy understory of deciduous and mixed woodlands; breeds in brushy vegetation, typically willow thickets, along rivers and streams.	Documented during PacifiCorp surveys primarily in wetland and riparian habitats along J.C. Boyle peaking reach, at Copco Reservoir, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Tricolored blackbird	*Agelaius tricolor*	FSC, BLM, SP, ONHP List 2, CSSC	Scrub-shrub wetland, emergent wetland, and riparian shrubland. Documented in Keno pool area. Range includes Klamath basin.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Black-throated sparrow	*Amphispiza bilineata*	BLM, SP, ONHP List 2	Annual grassland, perennial grassland, and mixed chaparral with sparse shrub canopy closure (<25 percent). Range lies east of the Project region.	Not documented during PacifiCorp surveys.
Mammals				
Preble's shrew	*Sorex preblei*	FSC, ONHP List 4	Streams; near permanent water or intermittent streams in arid to semi-arid shrub/grass associations and within high-elevation conifer forests; sagebrush thickets and willows. Range only extends into extreme eastern Klamath County.	Not documented during PacifiCorp surveys.
Pallid bat	*Antrozous pallidus pacificus*	FSC, BLM, SV, ONHP List 2, CSSC	Most common in open habitats but occurs in a wide variety of cover types including forests. Range overlaps the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Townsend's western big-eared bat	*Corynorhinus townsendii townsendii*	FSC, BLM, SC, ONHP List 2, CSSC	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence.	Known from J.C. Boyle peaking reach but not documented during PacifiCorp surveys. One occurrence in project area listed as sensitive by ORBIC (2010). Not listed on CNDDB for project area (CNDDB 2010).
Silver-haired bat	*Lasionycteris noctivagans*	FSC, BLM, SU, ONHP List 4	Montane hardwood forests, riparian forests, juniper, and all conifer forests with moderate to dense shrub canopy closure (>39 percent). Range overlaps the study area.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Small-footed myotis bat	*Myotis ciliolabrum*	FSC, BLM, SU, ONHP List 4	Associated with cliffs and rocky canyons, ponderosa pine and mixed conifer forests.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Long-eared myotis bat	*Myotis evotis*	FSC, BLM, SU	All forests, mixed chaparral, sagebrush, and forest edges. Range overlaps the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Fringed myotis bat	*Myotis thysanodes*	FSC, BLM, SV, ONHP List 2	All forests, particularly riparian forests. Range overlaps the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Long-legged myotis bat	*Myotis volans*	FSC, BLM, SV, ONHP List 4	All forests, including coniferous forests, oak woodlands, riparian forests. Range overlaps the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Yuma myotis bat	*Myotis yumanensis*	FSC, BLM, ONHP List 4	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence.	Documented during PacifiCorp surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse. Also known from J.C. Boyle peaking reach. One occurrence outside project area (CNDDB 2010).
Pygmy rabbit	*Brachylagus idahoensis*	FSC, SV, ONHP List 2, CSSC	Associated with areas supporting tall, dense clumps of sagebrush. Also may occur in greasewood stands. Project region lies west of the known species' range.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*	FSC, CSSC	Riparian deciduous forest, riparian shrub, mixed chaparral, ponderosa pine forest, Klamath mixed conifer forest, montane hardwood oak woodland, montane hardwood oak-juniper, and montane hardwood oak-conifer with trees greater than 11 inches dbh. Restricted to California well south of the study area.	Not documented during PacifiCorp surveys.
White-tailed jackrabbit	*Lepus townsendii*	BLM, SU, ONHP List 4	Sagebrush, mixed chaparral, perennial grassland, and montane hardwood oak-juniper, with sparse to open tree canopy closure (<40 percent). Range overlaps the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Western gray squirrel	*Sciurus griseus*	BLM, SU, ONHP List 4	Found in a variety of forested habitat types including mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak juniper with trees greater than 6 inches in diameter.	Documented during PacifiCorp surveys at J.C. Boyle and Copco Reservoirs, along J.C. Boyle peaking reach, and along Copco bypass reach.
White-footed vole	*Arborimus (=Phenacomys) albipes*	FSC, SU, ONHP List 4, CSSC	Riparian deciduous forest (usually alder) areas surrounded by conifer forests. Range is restricted to the Coast and Cascade Ranges well north of the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Oregon red tree vole	*Arborimus longicaudus*	FSC, S/M-C, ONHP List 3	Dense moist coniferous forests. Range is restricted to the Coast and Cascade Ranges well north of the study area.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Sonoma tree vole	*Arborimus pomo*	CSSC	North Coast fog belt from Oregon border to Sonoma County in Douglas Fir, redwood and montane hardwood-conifer forests.	Not documented during PacifiCorp surveys. Documented at north end of Williams Ridge, west of Weitchpec outside of project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Sierra Nevada red fox	*Vulpes vulpes necator*	FSC, CT	All habitats, especially forest, riparian, and chaparral habitat. Range occurs south of Siskiyou County.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Ringtail	*Bassariscus astutus*	BLM, SU, ONHP List 4	Uses a mixture of forest and shrublands or other habitats that provide vertical structure near rocky or riparian areas. Range overlaps the study area. The species is known to occur in the study area.	Not documented during PacifiCorp surveys. Documented in Klamath River Canyon (ORBIC 2010). Not listed on CNDDB for project area (CNDDB 2010).
American (Humboldt) marten	*Martes americana (humboldtensis)*	FSC, BLM, SV, ONHP List 4	Klamath mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak-conifer with moderate to dense tree canopy closure (>39 percent) and trees greater than 11 inches dbh. Habitat without human disturbance is important. Range overlaps the study area.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Fisher	*Martes pennanti*	FC, BLM, SC, ONHP List 2, CSSC	Mature, closed canopy forests with some deciduous trees; intermediate to large tree stages of conifer forests and riparian deciduous forests both with high tree canopy closure. Habitats in the study area include lodgepole pine, Klamath mixed conifer forest, ponderosa pine forest, riparian deciduous forest, montane hardwood oak-conifer with trees >11 inches dbh. Range overlaps the study area.	Not documented during PacifiCorp surveys. Documented along lower Klamath River (CNDDB 2010). Has been documented in the Upper Klamath Basin within the last two years (T. Collom, ODFW, personal communication, April 29, 2011).
American badger	*Taxidea taxus*	CSSC	Drier open stages of most shrub, forest, and herbaceous habitats with friable soils.	Not documented during PacifiCorp surveys. One occurrence outside project area (CNDDB 2010).
California wolverine	*Gulo gulo luteus*	FSC, OT, ONHP List 2	Lodgepole pine, Klamath mixed conifer forest, mixed chaparral, riparian deciduous forest. Open forests at higher elevations. Range in Oregon is restricted to Cascades well north of the study area. In California, range includes portions of Siskiyou County, but not the study area.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Canada lynx	*Lynx canadensis*	FT, ONHP List 2	Dense boreal forests, meadows, bogs. The last confirmed specimen in Oregon occurred in 1974. Range overlaps the study area in Oregon. Not in found in California.	Not documented during PacifiCorp surveys.
Gray wolf	*Canis lupus*	FT, OT, ONHP List 2-ex	Wide variety of habitats. Not known to occur in vicinity.	Not documented during PacifiCorp surveys.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
		Plants		
Pink sand-verbena	*Abronia umbellata* var. *breviflora*	CNPS List 1B	Coastal dunes and coastal strand with sparse cover.	Not documented during PacifiCorp surveys. Documented south of Klamath River mouth outside project area (CNDDB 2010).
Slender-stemmed androsace	*Androsace filiformis*	CNPS List 2	Wet, clay meadow soils with grasses and sedges, seen along stream bank in lodgepole pine disturbed by cattle; red fir forests; 1,800 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Slender silver moss	*Anomobryum julaceum*	CNPS List 2	Broad-leafed upland forest, lower montane coniferous forest.	Not documented during PacifiCorp surveys. Historical record south of Weitchpec (CNDDB 2010). Not in project area.
Waldo rock-cress	*Arabis aculeolata*	CNPS List 2	Broad-leafed upland forest, lower montane coniferous forest.	Not documented during PacifiCorp surveys. Historical record north of Douglas Creek, Southwest of Happy Camp (CNDDB 2010). Not in project area.
Crater Lake rock-cress	*Arabis suffrutescens var. horizontalis*	FSC, OC ONHP List 1	Dry, rocky, pumice or sandy slopes, usually in sparse pine or hemlock forest; 1,500 to 2,700 m.	Not documented during PacifiCorp surveys.
Klamath manzanita	*Arctostaphylos klamathensis*	FSC, ONHP List 1, CNPS List 1B	Montane chaparral, subalpine conifer forest, upper montane conifer forest, sometimes on serpentinitic or gabbro substrates.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Shasta arnica	*Arnica viscosa*	ONHP List 2	Rocky places at or above timberline in subalpine and alpine habitats.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Green-flowered wild-ginger	*Asarum wagneri*	BLM, OC, ONHP List 4	Conifer forests, often with *Abies* spp. or *Pinus ponderosa*.	Not documented during PacifiCorp surveys.
Grass-fern or northern spleenwort	*Asplenium septentrionale*	ONHP List 2	Cracks and crevices of rock outcrops and large boulders at elevations of 2,000-10,000 feet within mixed conifer forest.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Applegate's milk-vetch	*Astragalus applegatei*	FE, OE, ONHP List 1	Occurs in flat-lying, seasonally moist, strongly alkaline soils.	Documented during PacifiCorp surveys at Keno Impoundment.
Peck's milk-vetch	*Astragalus peckii*	FSC, OT, ONHP List 1	Dry *Artemisia tridentata/ Purshia tridentata* shrublands, sometimes in *Juniperus occidentalis* or *Pinus ponderosa* woodlands; sandy soils; 900 to 1,500 m.	Not documented during PacifiCorp surveys.
Bald Mountain milk-vetch	*Astragalus umbraticus*	CNPS List 2	Dry open oak and pine woodlands from 200-1,250 m.	Not documented during PacifiCorp surveys. Several records outside of project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Woolly balsamroot	*Balsamorhiza hookeri var. lanata*	BLM, ONHP List 1, CNPS List 1B	Open woods and grassy slopes; 800 to 1,000 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Bensoniella	*Bensoniella oregano*	S/M- C, ONHP List 1, CNPS List 1B	Edges of meadows near seeps and small streams in *Abies* zones, often with *Senecio triangularis*, *Mitella ovalis*, *Viola glabella*, *Asarum caudatum*; 900 to 1,400 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Resin birch	*Betula pumila var. glandulifera*	CNPS List 2	Edges of bogs, meadows and springs in lower montane to subalpine conifer forests; 1,300 to 2,200 m. (= *B. glandulosa* v. *glandulifera*).	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Small groundcone	*Boschniakia hookeri*	CNPS List 2	North Coast coniferous forest in open woods, shrubby places from 90-885 m.	Not documented during PacifiCorp surveys. Documented near tributaries outside of project area (CNDDB 2010).
Lance-leaved grape fern	*Botrychium lanceolatum ssp. Lanceolatum*	ONHP List 2	Mesic to wet rocky slopes, meadows and woods in the montane to subalpine zones.	Not documented during PacifiCorp surveys.
Mingan moonwort	*Botrychium minganense*	S/M, ONHP List 2, CNPS List 2	Moist conifer forests, especially riparian *Thuja plicata* wetlands (but not wet enough to support *Lysichiton*) on duff; occasionally in subalpine meadows, ski slopes and mossy boulder fields under *Acer macrophyllum* or in open shrubland.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Mountain grapefern	*Botrychium montanum*	S/M, ONHP List 2, CNPS List 2	Shady *Thuja plicata* and *Picea engelmannii* forests with sparse understory, near swamps and streams, also in drier *Pseudotsuga menziesii* forest; 950-1800 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Pumice grape fern	*Botrychium pumicola*	FSC, OT, ONHP List 1	Fine pumice gravel lacking humus and on grassy slopes above 5,000 feet.	Not documented during PacifiCorp surveys.
Greene's mariposa-lily	*Calochortus greenei*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs primarily in annual grassland, wedgeleaf ceanothus chaparral, and oak and oak-juniper woodlands.	Documented during PacifiCorp surveys at Iron Gate Reservoir. Yellow starthistle, medusahead, and annual bromes form the dominant herb layer cover at nearly all of the sites where Greene's mariposa lily was observed. Also known to occur at Copco Reservoir and along J.C. Boyle peaking reach. Several occurrences on CNDDB along Klamath River (2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Long-haired startulip	*Calochortus longebarbatus var. longebarbatus*	FSC, BLM, ONHP List 1, CNPS List 1B	Seasonally wet meadows within pine forests or sagebrush communities; open, grassy meadows, clay soil; 1,000 to 1,500 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Single-flowered mariposa-lily	*Calochortus monanthus*	FSC, CNPS List 1A	Meadows and seeps in riparian scrub, at +/- 740 m.	Not documented during PacifiCorp surveys. Documented in a meadow along the Shasta River near Yreka, outside the project area (CNDDB 2010).
Siskiyou mariposa-lily	*Calochortus persistens*	FSC, ONHP List 1, CNPS List 1B	Lower montane conifer forest, North Coast conifer forest, open, rocky areas; 1,000 to 1,500 m.	Not documented during PacifiCorp surveys. Documented on CNDDB (2010) outside of the project area.
Abrupt-beaked sedge	*Carex abrupta*	ONHP List 2	Moist meadows and open forest between 4,600 and 11,000 feet.	Not documented during PacifiCorp surveys.
Capitate sedge	*Carex capitata*	ONHP List 2	Found on marshy meadows with acidic, coarse textured, loamy sandy soils between 5,000 and 12,800 feet.	Not documented during PacifiCorp surveys.
Bristly sedge	*Carex comosa*	ONHP List 2	Marshes, lake shores, and wet meadows.	Not documented during PacifiCorp surveys. Documented along east shore of J.C. Boyle Reservoir (ORBIC 2010).
Oregon sedge	*Carex halliana*	CNPS List 2	Pinyon-juniper woodland, meadows.	Not documented during PacifiCorps surveys. Documented outside of project area (CNDDB 2010).
Smooth-beaked sedge	*Carex integra*	ONHP List 2	Seasonally moist soil between 3,000 and 11,000 feet.	Not documented during PacifiCorp surveys.
Slender sedge	*Carex lasiocarpa var. americana*	OHNP List 2	Meadows and lake and pond shores between 5,000 and 7,000 feet. Generally found in standing water.	Not documented during PacifiCorp surveys.
Meadow sedge	*Carex praticola*	ONHP List 2, CNPS List 2	Moist to wet meadows below 10,500 feet in elevation.	Not documented during PacifiCorps surveys. Documented outside of project area (CNDDB 2010).
Brown fox sedge	*Carex vulpinoidea*	CNPS List 2	Near water on moist open ground in swamps, prairie swales, lowland forests, wet ditches, ravines, and along the edges of marshes, springs, lakes, and ponds.	Not documented during PacifiCorp surveys. Documented on north shore of Iron Gate Reservoir, 0.1 mile downstream from mouth of Fall Creek (CNDDB 2010).
Oregon coast paintbrush	*Castilleja affinis* ssp. *litoralis*	CNPS List 2	Coastal bluff scrub, coastal dunes, coastal scrub.	Not documented during PacifiCorp surveys. Documented outside of project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Green-tinged paintbrush	*Castilleja chlorotica*	FSC, BLM, ONHP List 1	Open areas in ponderosa pine or mixed conifer forests; loose, sandy soils with *Penstemon davidsonii*, *Artemisia tridentata*, *Heuchera cylindrica*; hemiparasitic several shrubs most notably mountain big sagebrush; 1,900 to 2,500 m.	Not documented during PacifiCorp surveys.
Bulb-bearing water hemlock	*Cicuta bulbifera*	BLM, ONHP List 2ex	Marshes, bogs, wet meadows, shallow ponds; 70 to 1,150 m.	Not documented during PacifiCorp surveys.
Ashland thistle	*Cirsium ciliolatum*	BLM, ONHP List 1, CE, CNPS List 2	Dry, rocky, grassland; open woodland on south aspects; 800 to 1,400 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Mt. Mazama collomia	*Collomia mazama*	FSC, BLM, ONHP List 1	Alpine meadows and slopes; dry rocky places conifer forests; 900 to 1,850 m.	Not documented during PacifiCorp surveys.
Oregon goldthread	*Coptis laciniata*	CNPS List 2	North coast coniferous forest, meadows and seeps.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Pallid bird's-beak	*Cordylanthus tenuis ssp. pallescens*	FSC, CNPS List 1B	Lightly disturbed openings in ponderosa pine, Jeffrey pine, and mixed conifer forests; gravelly alluvium, volcanic or ultramafic soils; 1,100 to 1,700 m.	Not documented during PacifiCorp surveys. Documented on tributaries outside of the project area (CNDDB 2010).
Clustered lady's slipper	*Cordylanthus tenuis ssp. pallescens*	FSC, BLM, S/M- C, ONHP List 1, CNPS List 4	Dry, open conifer forests, sometime in moist riparian habitats, many soil types; 350 to 950 m (to 1,800 m in California).	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Mountain lady's slipper	*Cypripedium montanum*	BLM, S/M, ONHP List 4, CNPS List 4	Occurs in dry, open conifer forests, but more often in moist riparian habitats.	Documented during PacifiCorp surveys on a shaded and mesic, forested slope above Frain Creek, a small tributary to the Klamath River at Frain Ranch along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).
Naked flag moss	*Discelium nudum*	CNPS List 2	Coastal bluff scrub.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Oregon fireweed	*Epilobium oreganum*	FSC, ONHP List 1, CNPS List 1B	Wet, gently sloping stream banks, meadows, and bogs, sometimes generally on ultramafic soil; 50 to 2,500 m.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Klamath Mountain buckwheat	*Eriogonum hirtellum*	CNPS List 1B	Lower montane and upper montane coniferous forest on rocky outcrops and ridges.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Del Norte buckwheat	*Eriogonum nudum* var. *paralinum*	CNPS List 2	Coastal bluff scrub, coastal prairie.	Not documented during PacifiCorp surveys. Documented on sand bar at mouth of Klamath River (CNDDB 2010).
Prostrate buckwheat	*Eriogonum prociduum*	FSC, ONHP List 1, CNPS List 1B	Basalt flows in pine woodlands, occasionally on barren volcanic tuff; with *Artemisia* spp. and *Juniperus;* 1,300 to 2,705 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Blushing wild buckwheat	*Eriogonum ursinum* var. *erubescens*	CNPS List 1B	Rocky openings on open ridgelines in the Klamath Range from 5,300 to 6,200 feet.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Henderson's fawn lily	*Erythronium hendersonii*	CNPS List 2	Lower montane yellow pine forest. 300 to 1,600 m.	Not documented during PacifiCorp surveys. One occurrence listed as sensitive on CNDDB (2010).
Giant fawn lily	*Erythronium oregonum*	CNPS List 2	Cismontane woodlands, meadows and seeps.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Coast fawn lily	*Erythronium revolutum*	CNPS List 2	Bogs and fens, broad-leaved upland forest, north coast coniferous forest.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Gentner's fritillary	*Fritillaria gentneri*	FE, OE, CNPS List 1B	Variety of habitats including shaded riparian areas, open grasslands, and chaparral, but generally prefers the ecotone between meadow and oak woodland.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Newberry's gentian	*Gentiana newberryi var. newberryi*	BLM, ONHP List 2	Meadows and seeps. Moist conditions in meadows and along streambanks; 1,200 to 2,200 m.	Not documented during PacifiCorp surveys.
Klamath gentian	*Gentiana plurisetosa*	FSC, ONHP List 4, CNPS List 1B	Lower and upper montane conifer forest, meadows and seeps, mesic; 1,000 to 3,000 m.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Bolander's sunflower	*Helianthus bolanderi*	BLM, ONHP List 3	Occurs in yellow pine forest, foothill oak woodland, chaparral, and occasionally in serpentine substrates or wet habitats.	Documented during PacifiCorp surveys in highly disturbed and degraded sites filled with annual bromes and starthistle along the lower reach of Hayden Creek, a tributary to the Klamath River along J.C. Boyle peaking reach, and south of Iron Gate Reservoir.
Salt heliotrope	*Heliotropium curvasassavicum*	BLM, ONHP List 2	Occurs in seasonally flooded, low-lying, non-porous areas on the east side of the Cascades.	Documented during PacifiCorp surveys at the upper end of Keno Impoundment.
Vanilla grass	*Hierochloe odorata*	BLM, ONHP List 3, CNPS List 2	Meadows, seeps; 1,500 to 1,830 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Baker's globe mallow	*Iliamna bakeri*	BLM, ONHP List 1	Chaparral with manzanita, mountain mahogany, open ponderosa pine forest and juniper woodland. Open canopies, dry sandy soils and upper slopes, often in burned areas (Oregon) and/or volcanic lava fields (California); 1,500 to 2,000m (2,300m in California).	Not documented during PacifiCorp surveys.
California globe mallow	*Iliamna latibracteata*	CNPS List 1B	North Coast coniferous forest.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Pickering's ivesia	*Ivesia pickeringii*	FSC, CNPS List 1B	Lower montane conifer forest, meadows and seeps; mesic, clay, generally serpentinitic clay soils; 800 to 1,500m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Dudley's rush	*Juncus dudleyi*	CNPS List 2	Lower montane coniferous forest.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Heckner's lewisia	*Lewisia cotyledon var. heckneri*	FSC, ONHP List 4, CNPS List 1B	Open to partially shaded rocky slopes; +/- 1,500 to 1,600 m.	Not documented during PacifiCorp surveys. Two occurrences listed as sensitive (CNDDB 2010).
Howell's lewisia	*Lewisia cotyledon var. howellii*	FSC, ONHP List 4, CNPS List 3	Oak woodlands, in rock crevices, gravel, shallow loam or duff; 150 to 400 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Kellog's lily	*Lilium kelloggii*	FSC	Dry slopes with wet winters and some summer moisture.	Not documented during PacifiCorp surveys or listed by CNDDB (2010) for project area.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Bellinger's meadow-foam	*Limnanthes floccosa ssp. bellingerana*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs in rocky, seasonally wet meadows, or along the margins of damp rocky meadows often partially shaded by adjacent trees and shrubs.	Not documented during PacifiCorp surveys. Known to occur along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).
Coast Range lomatium	*Lomatium martindalei*	CNPS List 2	Bogs and seeps in lower montane coniferous forest, coast bluff scrub, meadows.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Peck's lomatium	*Lomatium peckianum*	CNPS List 2	Rocky slopes and flats or grassy slopes in ponderosa pine and black oak woodland on volcanic soils and pinyon-juniper woodland; 700 to 1,800 m.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Bog club-moss	*Lycopodiella inundata*	ONHP List 2	Wet organic soils in peat bogs, muddy depressions, and pond margins.	Not documented during PacifiCorp surveys or listed by CNDDB (2010) for project area.
Broad-nerved hump moss	*Meesia uliginosa*	CNPS List 2	Fens, peaty soil banks, seeps, meadows, and rock fissures upon exposed, damp organic soil within upper montane to subalpine coniferous forest.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Detling's silverpuffs	*Microseris laciniata* ssp. *detlingii*	CNPS List 2	Chaparral and grassy openings among Oregon white oak trees.	Not documented during PacifiCorp surveys. Documented west of Iron Gate Reservoir, 1.2 miles north of Klamath River bridge at Iron Gate Dam (CNDDB 2010).
Elongate copper moss	*Mielichhoferia elongata*	CNPS List 2	Cismontane woodlands.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Disappearing monkeyflower	*Mimulus evanescens*	FSC, OC, ONHP List 1, CNPS List 1B	Within sagebrush-juniper dominated vegetation zones and rock fragments and alongside small boulders.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Jepson's monkeyflower	*Mimulus jepsonii*	ONHP List 4, CNPS List 4	Bare gravelly, sandy, pumice soils in conifer forests; more than 1,000 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Egg Lake monkeyflower	*Mimulus pygmaeus*	FSC, CNPS List 4	Occurs in damp areas or vernally moist conditions in meadows and open woods.	Documented during PacifiCorp surveys on the southwest end of J.C. Boyle Reservoir in damp mudflats adjacent to shallow and narrow tributaries to the Reservoir and under the transmission line just southwest of J.C. Boyle Dam. Not listed on CNDDB for project area (CNDDB 2010).
Three-colored monkeyflower	*Mimulus tricolor*	ONHP List 2	Moist flats, wet clay soils and vernal pools. Plants bloom in the receding muds of ephemeral creeks, and stock ponds when sufficient snowpack provides spring water.	Not documented during PacifiCorp surveys.
Ghost-pipe	*Monotropa uniflora*	CNPS List 2	Broad-leaved upland forest, north coast coniferous forest.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Howell's montia	*Montia howellii*	CNPS List 2	Meadows, North coast coniferous forest, vernal pools.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Wolf's evening-primrose	*Oenothera wolfii*	CNPS List 1B	Coastal bluff scrub, coastal dunes, coastal prairie, lower montane coniferous forest.	Not documented during PacifiCorp surveys. Documented along lower Klamath River (CNDDB 2010).
Northern adder's tongue	*Ophioglossum pusillium*	FSC, CNPS List 1A	Freshwater wetlands or moist areas in forests, wetland edges. Low pastures and grassy roadside ditches; 1,000 to 2,000 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Slender orcutt grass	*Orcuttia tenuis*	FT, CE, CNPS List 1B	Vernal pools; 200 to 1,100 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Thread-leaved beardtongue	*Penstemon filiformis*	CNPS List 1B	Cismontane woodland, lower montane coniferous forest, meadows and seeps.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Blue-leaved penstemon	*Penstemon glaucinus*	FSC, BLM, ONHP List 1	Dry, fine, ashy soils or weathered tuff in forest openings and sometimes in high intensity burn sites, ponderosa pine and lodgepole pine forest; 1,900 to 2,650 m.	Not documented during PacifiCorp surveys.
Red-root yampah	*Perideridia erythrorhiza*	FSC, BLM, OC, ONHP List 1	Occurs in moist prairies, pastureland, seasonally wet meadows, and oak or pine woodlands, often in dark wetland soils and clay depressions.	Not documented during PacifiCorp surveys. Known to occur along Keno reach, at J.C. Boyle Reservoir, and along J.C. Boyle peaking reach.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Howell's false caraway	*Perideridia howellii*	BLM, ONHP List 4	Moist meadows, stream banks; 300 to 1,500 m.	Not documented during PacifiCorp surveys.
Cooke's phacelia	*Phacelia cookei*	FSC, CNPS List 1B	Great Basin scrub, lower montane conifer forest; sandy volcanic soil; 1,400 to 1,700 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Playa phacelia	*Phacelia inundata*	FSC, ONHP List 1, CNPS List 1B	Great Basin scrub, lower montane conifer forest, playas; alkaline soils; 1,300 to 1,800 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Moss phlox	*Phlox muscoides*	CNPS List 2	Alpine fell fields to subalpine conifer to great basin scrub in low sagebrush with narrow leaf mountain mahogany; 1,200 to 2,700 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
American pillwort	*Pilularia americana*	BLM, ONHP List 2	Shallow pools, vernal pools; 0 to 1,600 m.	Not documented during PacifiCorp surveys.
White-flowered rein orchid	*Piperia candida*	CNPS List 1B	North coast coniferous forest, lower montane coniferous forest, broad-leafed upland forest.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Desert allocarya	*Plagiobothrys salsus*	FSC, ONHP List 2, CNPS List 2	Moist, alkaline mud flats within the Mohave desert of California and Nevada.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Profuse-flowered mesa mint	*Pogogyne floribunda*	FSC, BLM, ONHP List 1, CNPS List 1B	Vernal pools and seasonal lakes sometimes dominated by *Artemisia cana*, *Poa secunda* and *Navarretia* sp.; 1,000 to 1,500 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Oregon polemonium	*Polemonium carneum*	CNPS List 2	Woody thickets, open and moist forests, prairie edges, roadsides, and fence lines.	Not documented during PacifiCorp surveys. Documented outside project area (CNDDB 2010).
Rafinesque's pondweed	*Potamogeton diversifolius*	ONHP List 2	Found in ponds, lakes, rivers and streams up to 8,200 feet.	Not documented during PacifiCorp surveys.
Newberry's cinquefoil	*Potentilla newberryi*	CNPS List 2	Marshes and swamps, receding shorelines, drying marsh margins, sandy volcanic soils; 1,290 to 2,200 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Western black currant	*Ribes hudsonianum var. petiolare*	CNPS List 1	Riparian scrub; 1,500 to 2,200 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Columbia yellow cress	*Rorippa columbiae*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs in cobbly, gravelly silt associated with seasonal creek drainages in ponderosa pine/juniper woodland, on the shores of alkalne lakes, along roadside ditches, in meadows, and seeps.	Documented during PacifiCorp surveys at Keno Impoundment. One occurrence at Klamath River near Orleans (CNDDB 2010).
Fleshy sage	*Salvia dorrii var. incana*	CNPS List 3	Occurs in silty to rocky soils in great basin scrub, pinyon, and juniper woodland.	Documented during PacifiCorp surveys on weathered bedrock outcrops overlain with thin, loose, and rocky substrate at Iron Gate Reservoir and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Tracy's sanicle	*Sanicula tracyi*	FSC, CNPS List 4	Mixed conifer or oak forests; 100 to 1,000 m.	Not documented during PacifiCorp surveys. Documented outside the project area (CNDDB 2010).
Scheuchzeria or pod grass	*Scheuchzeria palustris var. americana*	BLM, ONHP List 2, CNPS List 2	Freshwater wetlands, bogs, fens, lake margins; 1,400 to 2,000 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Slender bulrush	*Scirpus heterochaetus*	BLM, ONHP List 3, CNPS List 1B	Marshes, muddy shores of lakes at lower elevations, tolerant of alkali (like *S. acutus*); 500 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Pendulous bulrush	*Scirpus pendulus*	BLM, ONHP List 2, CNPS List 2	Occurs along streambanks and in wet meadows.	Documented during PacifiCorp surveys along Fall Creek and J.C. Boyle peaking reach. Documented outside project area (CNDDB 2010).
Water bulrush	*Scirpus subterminalis*	ONHP List 2, CNPS List 2	Marshes and swales, montane lake margins.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Pale yellow stonecrop	*Sedum laxum* ssp. *flavidum*	CNPS List 4	Broad-leaved upland forest, chaparral, cismontane woodland, lower montane coniferous forest.	Not documented during PacifiCorp surveys. Documented outside of project area (CNDDB 2010).
Coast sidalcea	*Sidalcea oregana* ssp. *eximia*	CNPS List 1B	Meadows and seeps, north coast coniferous forest, lower montane coniferous forest.	Not documented during PacifiCorps surveys. Documented outside of project area (CNDDB 2010).
Lemmon's silene	*Silene lemmonii*	ONHP List 3	Open pine woodlands; 600 to 2,850 m.	Not documented during PacifiCorp surveys.

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Marble Mountain campion	*Silene marmorensis*	FSC, CNPS List 1B	Broad leaved upland forest, cismontane woodland, lower montane conifer forest; 850 to 1,000 m.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Fringed campion	*Silene nuda ssp. insectivora*	BLM, ONHP List 4	Dry meadows, lake shores, *Pinus ponderosa* and juniper woodlands, loam soils, sometimes alkaline; 1,420 to 1,500 m.	Not documented during PacifiCorp surveys.
Short-podded thelypody	*Thelypodium brachycarpum*	FSC, BLM, ONHP List 2, CNPS List 4	Occurs in meadows and open flats.	Documented during PacifiCorp's field surveys in low-lying saltgrass grassland at Keno Impoundment. Not listed on CNDDB for project area (CNDDB 2010).
Howell's thelypody	*Thelypodium howellii ssp. Howellii*	FSC, ONHP List 2, CNPS List 1B	Alkaline adobe meadows, Artemisia scrub; 1,200 to 1,500 m.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).
Robust false lupine	*Thermopsis robusta*	CNPS List 1B	North coast coniferous forest, broad-leaved upland forest.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Coastal triquetrella	*Triquetrella californica*	CNPS List 1B	Coastal bluff scrub, coastal scrub valley and foothill grasslands.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Howell's triteleia	*Triteleia grandiflora* var. *howellii*	CNPS List 2	Rocky areas in Great Basin scrub, pinyon/ juniper woodland; 700 to 1,500 m.	Not documented during PacifiCorp surveys. Documented outside of the project area (CNDDB 2010).
Lesser bladderwort	*Utricularia minor*	ONHP List 2, CNPS List 4	Low nutrient lakes and peatbog pools in lowland and montane zones from 135 to 4,000 feet.	Not documented during PacifiCorp surveys. Not listed on CNDDB for project area (CNDDB 2010).

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Bryophytes				
Liverwort	*Ptilidium californicum*	S/M	Conifer forests, on *Pseudotsuga menziesii*, *Abies* spp., *Tsuga heterophylla* trunks and logs; 450 to 2,000 m.	Not documented during PacifiCorp surveys.
Moss	*Schistostega pennata*	S/M, ONHP List 2	Crevices of root wads where humidity is high all year (e.g., adjacent to ponds, lakes and streams).	Not documented during PacifiCorp surveys.
Moss	*Tetraphis geniculata*	S/M, ONHP List 3	Rotten logs.	Not documented during PacifiCorp surveys.
Lichens				
Lichen	*Bryoria tortuosa*	S/M	Semi-open conifer forests, on bark of conifers and hardwoods.	Not documented during PacifiCorp surveys.
Lichen	*Hypogymnia duplicata*	S/M	Moist conifer forests, on *Pseudotsuga menziesii* and pine twigs, and on mosses over rocks.	Not documented during PacifiCorp surveys.
Lichen	*Leptogium burnetiae var. hirsutum*	S/M	On deciduous tree and shrub bark, rocks, mossy rocks.	Not documented during PacifiCorp surveys.
Lichen	*Lobaria linita*	S/M, ONHP List 2	Moist forests, on trees, shrubs, mossy rocks.	Not documented during PacifiCorp surveys.
Lichen	*Lobaria oregona*	S/M	Conifer forests; usually on conifer branches, occasionally on deciduous trees.	Not documented during PacifiCorp surveys.
Lichen	*Platismatia lacunose*	S/M	On bark and wood, especially Alnus in riparian forests and moist cool upland sites.	Not documented during PacifiCorp surveys.
Lichen	*Ramalina thrausta*	S/M	Low elevation moist forests, especially riparian fir or spruce; old-growth *Pseudotsuga menziesii* forests.	Not documented during PacifiCorp surveys.
Lichen	*Teloschistes flavicans*	S/M, ONHP List 2	Coastal headland forests, usually on *Picea sitchensis*.	Not documented during PacifiCorp surveys.
Lichen	*Usnea longissima*	S/M	Usually on riparian conifers and hardwoods at low elevations.	Not documented during PacifiCorp surveys. One occurrence outside of project area (CNDDB 2010).

*Information on occurrence in the project area is based on PacifiCorp surveys (FERC 2004) and information obtained from ORBIC and CNDDB databases (2010).

BLM = Bureau of Land Management sensitive species - species that could easily become endangered or extinct.

CC = Birds of Conservation Concern (FWS Division of Migratory Bird Management)

CE = California Endangered

CNPS List 1A = California Native Plant Society (CNPS)- Presumed extinct in California.

CNPS List 1B =rare, threatened, or endangered in California and elsewhere.

CNPS List 2 = rare, threatened, or endangered in California, but more common elsewhere.

CNPS List 3 = on the review list - more information needed

CNPS List 4 = on the watch list - limited distribution

CSSC = California Department of Fish and Game Species of Special Concern - not listed under the federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence

CT = California Threatened

FC = Federal Candidate Species

FD = Federal Delisted

Table I-1. Special-Status Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*

FE = Federal Endangered
FP: Fully protected under the California Fish and Game Code
FSC = Federal Species of Concern
FT = Federal Threatened
OC = Candidate listing by Oregon Department of Agriculture (ODA) or Oregon Department of Fish and Wildlife (ODFW)
OE = Listed as endangered by ODA or ODFW
ONHP List 1 = Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range
ONHP List 2 = threatened with extirpation or presumed to be extirpated from the state of Oregon
ONHP List 3 = more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range
OHNP List 4 = of conservation concern but not currently threatened or endangered
OT = Listed as threatened by ODA or ODFW
SC = Sensitive Critical - listed by ODFW as threatened or endangered is pending, or listing as threatened or endangered may be appropriate if immediate conservation actions are not taken.
SP = Sensitive Peripheral or Naturally Rare - listed by ODFW with populations on the edge of the range or historically low because of naturally occurring limiting factors
SU = Sensitive Undetermined Status - listed by ODFW for which status is unclear
SV = Sensitive Vulnerable - listed by ODFW as threatened or endangered is not imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring. In some cases the populations are sustainable and protective measures
S/M-C = Survey and Manage Species, as designated in the Northwest Forest Plan; category C - Uncommon, pre-disturbance surveys practical
S/M-D = Survey and Manage Species, as designated in the Northwest Forest Plan; category D - Uncommon, pre-disturbance surveys not practical or necessary

I.2 References

PacifiCorp. 2004. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). Portland, Oregon.

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Appendix J
Modeled Changes to the 100 year Floodplain

The Lead Agencies modeled flood events that meet criteria for a 100-year flood using daily average flows under the No Action/No Project Alternative condition and the Proposed Action. This appendix includes maps showing 100-year floodplain. The "With Dams 100 year" shown on the maps depicts the No Action/No Project Alternative condition and the "Without Dams 100 year" depicts the Proposed Action. All of the areas depicted on the following map are within Siskiyou County, California.

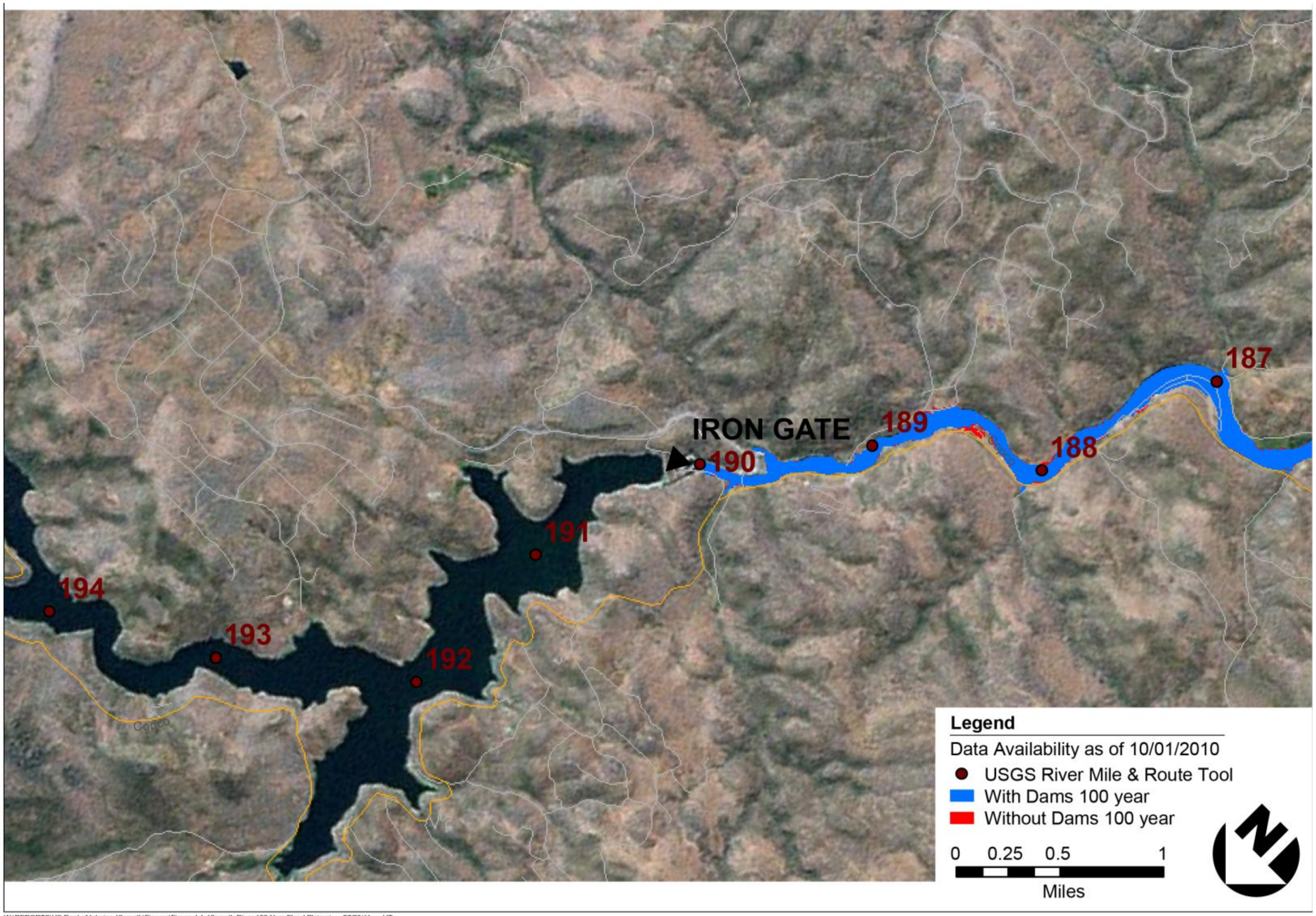

Figure J-1. Klamath River 100-Year Flood Plain (Sheet 1 – RMile 187-195)

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Figure J-2. Klamath River 100-Year Flood Plain (Sheet 2 – RMile 179-187)

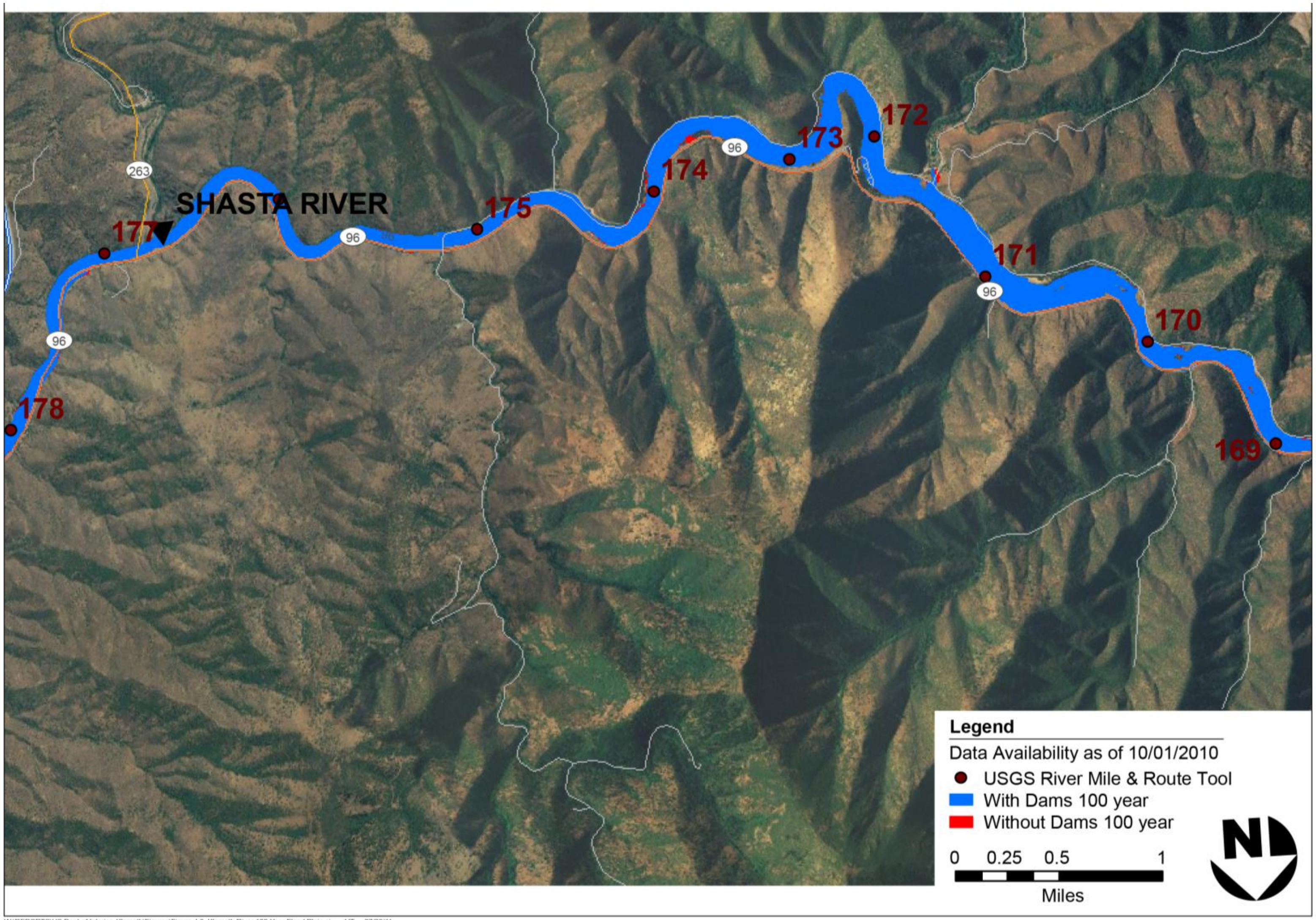
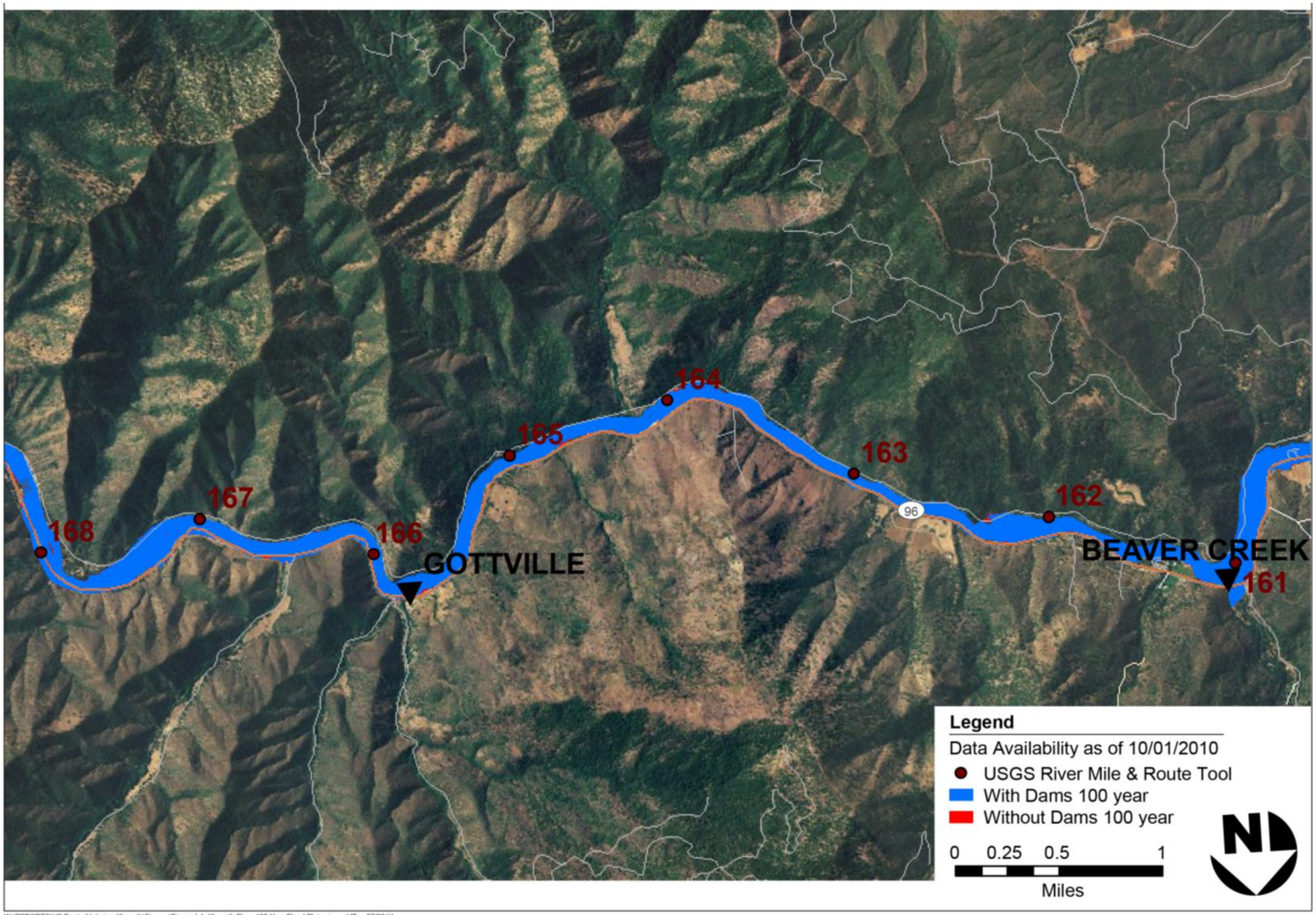


Figure J-3. Klamath River 100-Year Flood Plain (Sheet 3 – RMile 169-179)

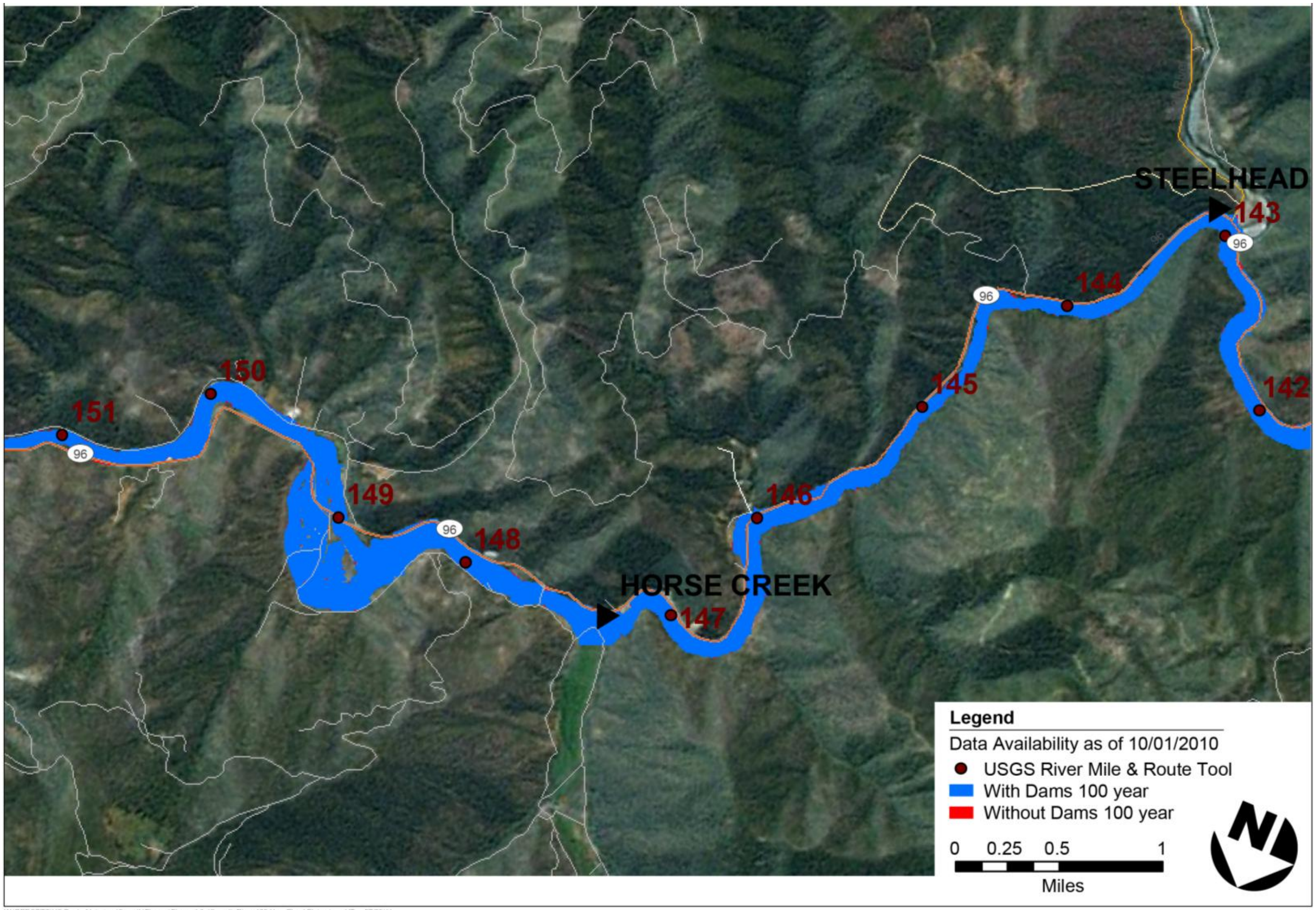


W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure J-4_Klamath River 100-Year Flood Plain.ai JJT 07/28/11

Figure J-4. Klamath River 100-Year Flood Plain (Sheet 4 – RMile 161-168)

W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure J-5_Klamath River 100-Year Flood Plain.ai JJT 07/28/11

Figure J-5. Klamath River 100-Year Flood Plain (Sheet 5 – RMile 152-161)



W:\REPORTS\US Dept of Interior Klamath\Figures\Figure J-6 Klamath River 100-Year Flood Plain.ai JJT 07/28/11

Figure J-6. Klamath River 100-Year Flood Plain (Sheet 6 – RMile 142-152)

Figure J-7. Klamath River 100-Year Flood Plain (Sheet 7 – RMile 134-142)

W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure J-8_Klamath River 100-Year Flood Plain.ai JJT 09/14/11

Figure J-8. Klamath River 100-Year Flood Plain (Sheet 8 – RMile 125-133)

Figure J-9. Klamath River 100-Year Flood Plain (Sheet 9 – RMile 109-125)

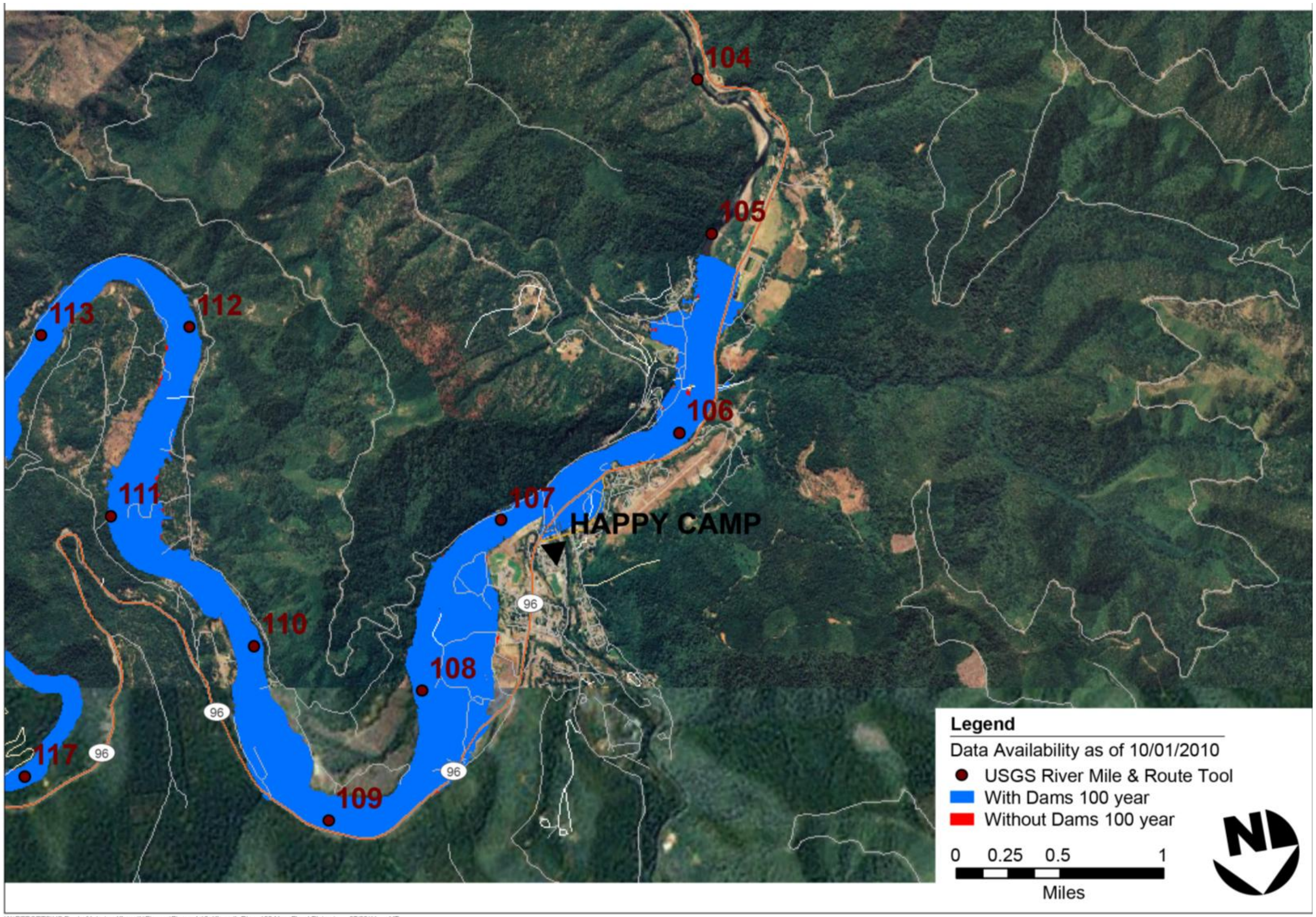


Figure J-10. Klamath River 100-Year Flood Plain (Sheet 10 – RMile 104-109)

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Appendix K
Groundwater Well Data

This appendix provides additional figures and tables showing groundwater well locations and data.

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J.C. Boyle Reservoir

Table K-1. Well Construction information for Wells Identified within 2.5 Miles of J.C. Boyle Reservoir.

Well ID	54713	54714	54615	13668	51633	54618	14002	13628	10514	10059
Ground Surface Elev (ft)	3797	3805	3781.6	3810	3827	3833.3	3876	3885	3876	3908
Nearest Reservoir	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle	JC Boyle
Dist. To Reservoir (ft)	29.5	62.3	65.6	183.7	203.4	278.9	2706.8	2884	4721.4	5518.6
Reservoir Elev. (ft)	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
Reservoir Bed, Upstream End(ft)	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
Reservoir Bed, Down\stream End(ft)	3720	3720	3720	3720	3720	3720	3720	3720	3720	3720
Top of Perforated Interval, Depth (ft bgs)	84.4	49.1	125.2	22	126	125.5	98	201	275	30
Top of Perforated Interval, Elev. (ft)	3712.6	3755.9	3656.4	3788	3701	3707.8	3778	3684	3601	3878
Bottom of Perforated Interval, Depth (ft bgs)	84.4	79.1	125.2	180	315	125.5	238	241	315	281
Bottom of Perforated Interval, Elev. (ft)	3712.6	3725.9	3656.4	3630	3512	3707.8	3638	3644	3561	3627
Depth (ft bgs)	84.4	79.1	125.2	180	315	125.5	238	281	324	281
Well Bottom Elev. (ft)	3712.6	3725.9	3656.4	3630	3512	3707.8	3638	3604	3552	3627
1st Water, Depth (ft bgs)				155	126		181	210	242	77
1st Water Elev (ft)				3655	3701		3695	3675	3634	3831
Water Bearing Zone, Depth (ft bgs)				155	126		181	210	230	203
Water Bearing Zone, Elev. (ft)				3655	3701		3695	3675	3646	3705
Pumping Rate (GPM)				15	55		25	30	40	12
Static Water Level, Depth (ft bgs)	20.3			120	126		178	204	189	222
Static Water Level, Elev. (ft bgs)	3776.8			3690	3701		3698	3681	3687	3686
Unit 1	0 to 20.7 ft bgs; tuff, bedded	0 to 22.7 ft bgs; tuff, bedded	0 to 5.2 ft bgs; alluvium	0 to 1 ft bgs; soil, brn	0 to 5 ft bgs; clay, brn w/ rock, broken	0 to 10.7 ft bgs; alluvium, gravelly	0 to 4 ft bgs; clay, brn, gravelly	0 to 5 ft bgs; topsoil w/ boulders	0 to 5 ft bgs; soil	0 to 1 ft bgs; topsoil
Unit 2	20.7 to 44.39 ft bgs; sediments, mixed	22.7 to 49.1 ft bgs; sediments, mixed	5.2 to 33.7 ft bgs; SDST w/ CGLT - tuff	1 to 22 ft bgs; clay, brn	5 to 19 ft bgs; basalt, gray, hard	10.7 to 16.7 ft bgs; silt, diatomaceous	4 to 19 ft bgs; clay, brn	5 to 25 ft bgs; lava, brn w/ clay	5 to 13 ft bgs; clay, brn	1 to 13 ft bgs; clay, brn
Unit 3	44.39 to 51.31 ft bgs; basalt, sheared	49.1 to 58.2 ft bgs; basalt, sheared	33.7 to 38.2 ft bgs; silt, diatomaceous	22 to 34 ft bgs; lava, blk	19 to 24 ft bgs; basalt, broken w/ ash, brn	16.7 to 50.5 ft bgs; SDST w/ CGLT - tuff	19 to 47 ft bgs; clay, gray, sandy	25 to 59 ft bgs; rock, blk	13 to 75 ft bgs; clay, blue	13 to 16 ft bgs; gravel, cemented
Unit 4	51.31 to 69.4 ft bgs; basalt, breccia	58.2 to 64.1 ft bgs; basalt, breccia	38.2 to 41.4 ft bgs; SDST - tuff	34 to 102 ft bgs; lava, brn	24 to 31 ft bgs; basalt, gray & brn, broken	50.5 to 54.5 ft bgs; silt, diatomaceous	47 to 56 ft bgs; clay, blk, sandy	59 to 71 ft bgs; cinders, brn	75 to 122 ft bgs; clay, brn	17 to 35 ft bgs; clay, brn
Unit 5	69.4 to 84.4 ft bgs; basalt	64.1 to 79.1 ft bgs; basalt	41.4 to 43.2 ft bgs; silt, diatomaceous	102 to 133 ft bgs; lava, red	31 to 50 ft bgs; basalt, gray, hard	54.5 to 56.7 ft bgs; SDST - tuff	56 to 71 ft bgs; clay, gray, gravelly	71 to 210 ft bgs; lava, blk	122 to 132 ft bgs; rock	35 to 77 ft bgs; clay, blue
Unit 6			43.2 to 73.7 ft bgs; sand, silty w/ silt - fluvial volcaniclastics	133 to 155 ft bgs; lava, blk	50 to 54 ft bgs; ash, brn w/ basalt	56.7 to 70.5 ft bgs; sand, silty w/ silt - fluvial volcaniclastics	71 to 87 ft bgs; clay, gray, sandy	210 to 226 ft bgs; cinders, red	132 to 230 ft bgs; rock, gray w/ clay, brn	77 to 101 ft bgs; clay, blue w/ streaks of blk sand
Unit 7			73.7 to 75.5 ft bgs; basalt flow top	155 to 180 ft bgs; CGLT, lava, brn	54 to 75 ft bgs; basalt, gray, hard	70.5 to 75 ft bgs; basalt flow top	87 to 92 ft bgs; clay, gray	226 to 261 ft bgs; lava, blk	230 to 281 ft bgs; rock, gray, broken	101 to 118 ft bgs; clay, blue
Unit 8			75.5 to 85.2 ft bgs; basalt A		75 to 92 ft bgs; ash, brn w/ basalt	75 to 85.5 ft bgs; basalt W	92 to 108 ft bgs; SDST, brn	261 to 277 ft bgs; cinders, red	281 to 305 ft bgs; rock, brn	118 to 134 ft bgs; SDST, gray
Unit 9			85.2 to 96.5 ft bgs; basalt X		92 to 101 ft bgs; basalt, gray, hard	85.5 to 100.7 ft bgs; basalt X	108 to 134 ft bgs; lava, brn, broken	277 to 282 ft bgs; lava, blk	305 to 324 ft bgs; rock, gray, broken	134 to 155 ft bgs; clay, blue w/ streaks of fine blk sand
Unit 10					101 to 118 ft bgs; ash, brn w/ basalt		134 to 154 ft bgs; volcanics, red & brn			155 to 184 ft bgs; clay, blue

Table K-1. Well Construction information for Wells Identified within 2.5 Miles of J.C. Boyle Reservoir.

Well ID	54713	54714	54615	13668	51633	54618	14002	13628	10514	10059
Unit 11					118 to 125 ft bgs; basalt, gray, hard		154 to 238 ft bgs; volcanics, gray, hard w/ water			184 to 203 ft bgs; SDST, brn & clay
Unit 12					125 to 127 ft bgs; basalt, gray, fract'd w/ water					203 to 212 ft bgs; lava, brn w/ clay
Unit 13					127 to 148 ft bgs; basalt, brn & gray, broken w/ water					212 to 215 ft bgs; rock, blk
Unit 14					148 to 152 ft bgs; ash, brn w/ basalt w/ water					215 to 223 ft bgs; lava, brn w/ clay
Unit 15					152 to 167 ft bgs; basalt, gray, hard					223 to 238 ft bgs; rock, gray w/ clay
Unit 16					167 to 192 ft bgs; basalt, fract'd, broken w/ water					238 to 257 ft bgs; rock, gray
Unit 17					192 to 206 ft bgs; basalt, gray, hard w/ water					257 to 280 ft bgs; lava, brn, bubbly
Unit 18					206 to 209 ft bgs; ash, fract'd, soft					280 to 281 ft bgs; rock, gray
Unit 19					192 to 206 ft bgs; basalt, gray, hard w/ water					257 to 280 ft bgs; lava, brn, bubbly
Unit 20					206 to 209 ft bgs; ash, fract'd, soft					280 to 281 ft bgs; rock, gray
Unit 21					209 to 231 ft bgs; basalt, gray, hard w/ water					
Unit 22					231 to 234 ft bgs; basalt, broken w/ water					
Unit 23					234 to 270 ft bgs; basalt, gray, hard w/ water					
Unit 24					270 to 273 ft bgs; basalt, gray, fract'd w/ water					
Unit 25					273 to 291 ft bgs; basalt, gray, hard					
Unit 26					291 to 308 ft bgs; basalt, broken w/ ash w/ water					
Unit 27					308 to 315 ft bgs; basalt, gray, caving					

Table K-2. Abbreviations Used to Characterize Geologic Units in Well Logs

Materials	
SDST	sandstone
CLST	claystone
BRNST	brownstone
GRST	graystone
SH	shale
CGLT	conglomerate
BDRK	bedrock
SPTN	serpentine
SLT	silt
MDST	mudstone
Colors	
brn	brown
lt	light
grn	green
dk	dark
brnsh	brownish
grnsh	greenish
blk	black
Other	
decomp'd	decomposed
fract'd	fractured
interm't	intermittent
crs	coarse
am't	amount
med	medium
lgr	large
sm	small
comp'd	compacted
N/R	No recovery, no log, or illegible log

Copco 1 and Copco 2 Reservoirs

Table K-3. Well Construction information for Wells Identified within 2.5 Miles of Copco 1 and Copco 2 Reservoirs.

Well ID	70943	555722	406066	512954	555712	113378	93347	406065	713255	1075453	750784
Ground Surface Elev (ft)	2623.5	2624.8	2686.4	2613.4	2642.7	2637.3	2655.4	2657.6	2624.9	2690.4	2676.3
Nearest Reservoir	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco
Dist. To Reservoir (ft)	39.4	55.8	85.3	98.4	154.2	160.8	183.7	196.9	196.9	239.5	242.8
Reservoir Elev. (ft)	2602	2602	2602	2602	2602	2602	2602	2602	2602	2602	2602
Reservoir Bed, Upstream End(ft)	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
Reservoir Bed, Down\stream End(ft)	2493	2493	2493	2493	2493	2493	2493	2493	2493	2493	2493
Top of Perforated Interval, Depth (ft bgs)	70	23	49	75	100	16	15	200	104	50	460
Top of Perforated Interval, Elev. (ft)	2553.5	2601.8	2637.4	2538.4	2542.7	2621.3	2640.4	2457.6	2520.9	2640.4	2216.3
Bottom of Perforated Interval, Depth (ft bgs)	84	184	300	225	120	75	110	200	124	200	500
Bottom of Perforated Interval, Elev. (ft)	2539.5	2440.8	2386.4	2388.4	2522.7	2562.3	2545.4	2457.6	2500.9	2490.4	2176.3
Depth (ft bgs)	90	184	300	384	220	75	110	200	124	200	510
Well Bottom Elev. (ft)	2533.5	2440.8	2386.4	2229.4	2422.7	2562.3	2545.4	2457.6	2500.9	2490.4	2166.3
1st Water, Depth (ft bgs)	32		180			49		150		80	
1st Water Elev (ft)	2591.5		2506.4			2588.3		2507.6		2610.4	
Water Bearing Zone, Depth (ft bgs)											
Water Bearing Zone, Elev. (ft)											
Pumping Rate (GPM)		13	0.1	2	15	25	20	0.8	30	17	40
Static Water Level, Depth (ft bgs)	15	40		50	80	40	15	60	60	35	60
Static Water Level, Elev. (ft bgs)	2608.5	2584.8		2563.4	2562.7	2597.3	2640.4	2597.6	2564.9	2655.4	2616.3
Unit 1	0 to 32 ft bgs; clay w/ boulders	0 to 10 ft bgs; clay, tan	0 to 21 ft bgs; clay, blk	0 to 18 ft bgs; SH, gray	0 to 40 ft bgs; clay, brn	0 to 20 ft bgs; adobe w/ boulders	0 to 15 ft bgs; clay, brn	0 to 18 ft bgs; clay, blk	0 to 22 ft bgs; adobe, brn	0 to 6 ft bgs; clay, blk	0 to 384 ft bgs; No Log
Unit 2	32 to 33 ft bgs; gravel w/ water	10 to 184 ft bgs; rock, blue-grn w/ qtz stringers	21 to 25 ft bgs; clay, yellow	18 to 97 ft bgs; SH, brn	40 to 75 ft bgs; clay, tan	20 to 49 ft bgs; soil w/ rock	15 to 30 ft bgs; soil, diatomac eous earth	18 to 21 ft bgs; clay, white	22 to 75 ft bgs; adobe, gray	6 to 25 ft bgs; clay, yellow	384 to 390 ft bgs; rock, brn, fract'd

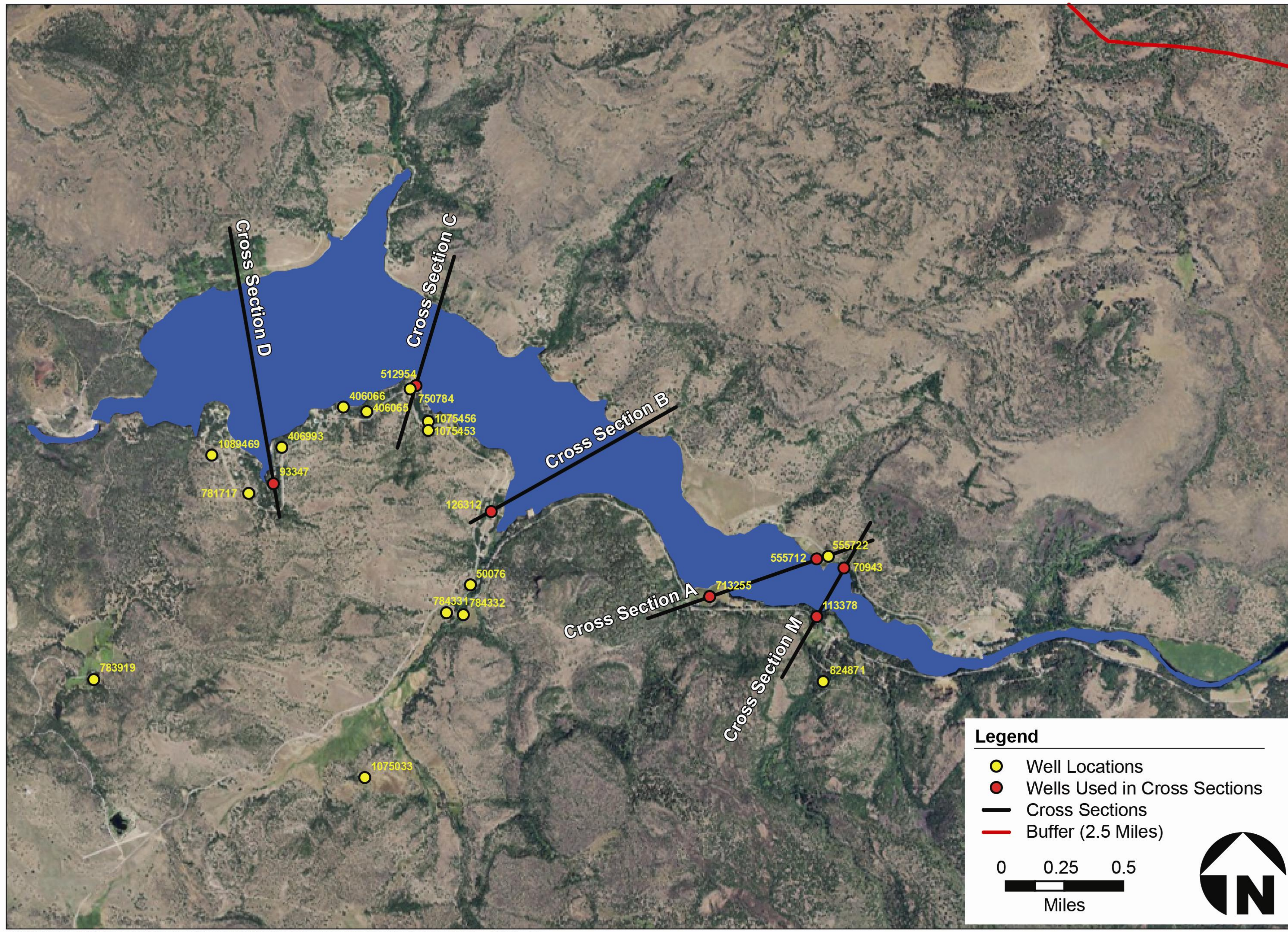
Well ID	406993	126312	1075456	781717	1089469	824871	50076	784332	784331	783919	1075033
Ground Surface Elev (ft)	2657.6	2636.1	2657.6	2700.1	2727.8	2775.5	2667.5	2672.6	2688	2866.8	2995.9
Nearest Reservoir	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco	Copco
Dist. To Reservoir (ft)	259.2	272.3	420	429.8	547.9	1148.4	1335.4	2004.7	2142.5	5325.1	6276.6
Reservoir Elev. (ft)	2602	2602	2602	2602	2602	2602	2602	2602	2602	2602	2602
Reservoir Bed, Upstream End(ft)	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
Reservoir Bed, Down\stream End(ft)	2493	2493	2493	2493	2493	2493	2493	2493	2493	2493	2493
Top of Perforated Interval, Depth (ft bgs)	152	63	50	40	28	140	44	130	95	140	31
Top of Perforated Interval, Elev. (ft)	2505.6	2573.1	2607.6	2660.1	2699.8	2635.5	2623.5	2542.6	2593	2726.8	2964.9
Bottom of Perforated Interval, Depth (ft bgs)	172	83	425	512	350	204	60	150	110	180	128
Bottom of Perforated Interval, Elev. (ft)	2485.6	2553.1	2232.6	2188.1	2377.8	2571.5	2607.5	2522.6	2578	2686.8	2867.9
Depth (ft bgs)	172	83	425	512	350	250	60	150	110	184	128
Well Bottom Elev. (ft)	2485.6	2553.1	2232.6	2188.1	2377.8	2525.5	2607.5	2522.6	2578	2682.8	2867.9
1st Water, Depth (ft bgs)			125	118	250	140	52	146	22		50
1st Water Elev (ft)			2532.6	2582.1	2477.8	2635.5	2615.5	2526.6	2666		2945.9
Water Bearing Zone, Depth (ft bgs)							52				
Water Bearing Zone, Elev. (ft)							2615.5				
Pumping Rate (GPM)	10	10	15	100	10	42	12	25	25	30	8
Static Water Level, Depth (ft bgs)	150	40	50	261	90	45	32	13	10	20	18
Static Water Level, Elev. (ft bgs)	2507.6	2596.1	2607.6	2439.1	2637.8	2730.5	2635.5	2659.6	2678	2846.8	2977.9
Unit 1	0 to 150 ft bgs; rock, tan	0 to 6 ft bgs; clay, brn	0 to 6 ft bgs; clay, blk	0 to 1 ft bgs; soil, blk	0 to 25 ft bgs; rock, brn, broken	0 to 9 ft bgs; clay, blk	0 to 5 ft bgs; clay, sticky	0 to 70 ft bgs; clay, brn w/ rock	0 to 22 ft bgs; topsoil w/ boulders	0 to 10 ft bgs; adobe	0 to 3 ft bgs; clay, blk
Unit 2	150 to 172 ft bgs; granite, broken, decomp'd	6 to 35 ft bgs; clay, lt brn, sticky	6 to 20 ft bgs; clay, yellow	1 to 15 ft bgs; SDST, brn	25 to 250 ft bgs; rock, gray, hard	9 to 16 ft bgs; clay, brn w/ cobbles	5 to 15 ft bgs; clay, brn & red	70 to 75 ft bgs; boulders, blue & gray	22 to 40 ft bgs; clay, blk w/ water	10 to 18 ft bgs; rock, grn, harder	3 to 12 ft bgs; clay, brn

Table K-3. Well Construction information for Wells Identified within 2.5 Miles of Copco 1 and Copco 2 Reservoirs.

Well ID	70943	555722	406066	512954	555712	113378	93347	406065	713255	1075453	750784	406993	126312	1075456	781717	1089469	824871	50076	784332	784331	783919	1075033
Unit 3	33 to 60 ft bgs; clay w/ boulders		25 to 44 ft bgs; sand & gravel w/ clay, brn	97 to 130 ft bgs; rock, reddish-tan	75 to 220 ft bgs; rock, blk & grn w/ qtz stringers	49 to 60 ft bgs; boulders, sm w/ water	30 to 45 ft bgs; clay, brn	21 to 32 ft bgs; ash, red	75 to 95 ft bgs; gravel, gray-blk, cobbly	25 to 45 ft bgs; CLST, white	390 to 500 ft bgs; rock, gray, decomp'd		35 to 65 ft bgs; clay, blue, sticky	20 to 35 ft bgs; CLST, white	15 to 30 ft bgs; CLST, yellow	250 to 251 ft bgs; rock, gray, fract'd w/ water	16 to 26 ft bgs; basalt	15 to 17.5 ft bgs; clay, brn & red, hard	75 to 146 ft bgs; clay, brn w/ rock	40 to 63 ft bgs; clay, brn w/ rock, sm	18 to 45 ft bgs; SH, brn	12 to 32 ft bgs; boulders w/ sand & gravel
Unit 4	60 to 75 ft bgs; clay, blk		44 to 180 ft bgs; SDST, gray	130 to 225 ft bgs; rock, lt tan w/ minor rock, gray w/ rock, red, hard			45 to 110 ft bgs; rock, brn	32 to 47 ft bgs; CLST, blue, caving	95 to 104 ft bgs; SH, brn	45 to 47 ft bgs; sand & gravel	500 to 510 ft bgs; rock, gray, hard, fract'd		65 to 70 ft bgs; sand, blue, cemented	35 to 95 ft bgs; basalt, blk	30 to 58 ft bgs; SPTN, blue	251 to 310 ft bgs; rock, gray, hard	26 to 35 ft bgs; gravel & cobbles	17.5 to 40 ft bgs; clay, white & gray	146 to 150 ft bgs; rock, broken w/ water	63 to 74 ft bgs; cinders, blk & brn & red	45 to 80 ft bgs; rock, grn, harder	32 to 42 ft bgs; clay, blue
Unit 5	75 to 90 ft bgs; rock		180 to 181 ft bgs; SDST, gray, broken w/ water	225 to 338 ft bgs; rock, white				47 to 98 ft bgs; CLST, blue	104 to 124 ft bgs; SH, grn, hard w/ rock, blk	47 to 80 ft bgs; basalt, blk			70 to 80 ft bgs; rock, brn, decomp'd	95 to 125 ft bgs; SDST, blue w/ qtz	58 to 60 ft bgs; SDST, brn	310 to 312 ft bgs; rock, gray, hard, fract'd	35 to 70 ft bgs; SH, brn w/ gravel	40 to 53 ft bgs; mud, blue w/ water		74 to 77 ft bgs; rock, brn broken	80 to 85 ft bgs; rock, blk w/ red color	42 to 50 ft bgs; rock, blue
Unit 6			181 to 300 ft bgs; SDST, gray	338 to 384 ft bgs; rock, reddish-tan				98 to 99 ft bgs; CLST, blue, broken		80 to 82 ft bgs; SDST, blue, w/ qtz w/ water			80 to 83 ft bgs; rock, brn, hard w/rock, blk	125 to 127 ft bgs; SDST, blue, fract'd w/ water	60 to 118 ft bgs; basalt, blue, hard	312 to 350 ft bgs; rock, gray, hard	70 to 95 ft bgs; SH, brn w/ qtz	53 to 60 ft bgs; rock		77 to 102 ft bgs; rock, brn, hard	85 to 90 ft bgs; rock, lt grn	50 to 52 ft bgs; rock, brn w/ water
Unit 7								99 to 150 ft bgs; clay, blue		82 to 95 ft bgs; SDST, blue				127 to 345 ft bgs; basalt, blk	118 to 119 ft bgs; basalt, brn, fract'd w/ water		95 to 135 ft bgs; rock, blue-gray w/ qtz			102 to 110 ft bgs; clay, blue	90 to 110 ft bgs; rock, blk & red, interbedded	52 to 85 ft bgs; rock, blue
Unit 8								150 to 151 ft bgs; CLST, blue, broken		95 to 140 ft bgs; basalt, blk				345 to 347 ft bgs; QTZ, fract'd w/ water	119 to 120 ft bgs; basalt, brn		135 to 150 ft bgs; SH w/ rock, blue-gray w/ qtz				110 to 180 ft bgs; rock, lt grn	85 to 87 ft bgs; rock, blue, fract'd w/ water
Unit 9								151 to 200 ft bgs; clay, blue		140 to 142 ft bgs; SDST, blue, fract'd w/ water				347 to 408 ft bgs; basalt, blk	120 to 135 ft bgs; basalt, blue		150 to 163 ft bgs; SH, purple				180 to 182 ft bgs; rock, brn, soft	87 to 128 ft bgs; rock, blue
Unit 10										142 to 180 ft bgs; basalt, blk				408 to 410 ft bgs; basalt, blk, fract'd w/ qtz w/ water	135 to 140 ft bgs; basalt, brn, fract'd w/ water		163 to 171 ft bgs; rock, blue-gray				182 to 184 ft bgs; rock, grn, hard	
Unit 11										180 to 182 ft bgs; SDST, blue, fract'd w/ water				410 to 425 ft bgs; basalt, blk	140 to 348 ft bgs; lava, blk, hard		171 to 260 ft bgs; SH, gray & blk					
Unit 12										182 to 200 ft bgs; SDST, blue					348 to 350 ft bgs; lava, blk w/ water							
Unit 13															350 to 376 ft bgs; ash, red							
Unit 14															376 to 378 ft bgs; lava, red w/ qtz w/ water							

Table K-3. Well Construction information for Wells Identified within 2.5 Miles of Copco 1 and Copco 2 Reservoirs.

Well ID	70943	555722	406066	512954	555712	113378	93347	406065	713255	1075453	750784	406993	126312	1075456	781717	1089469	824871	50076	784332	784331	783919	1075033
Unit 15															378 to 400 ft bgs; lava, blk, hard							
Unit 16															400 to 440 ft bgs; SPTN, grn							
Unit 17															440 to 510 ft bgs; basalt, blk							
Unit 18															510 to 512 ft bgs; basalt, blk, q/ qtz w/ water							



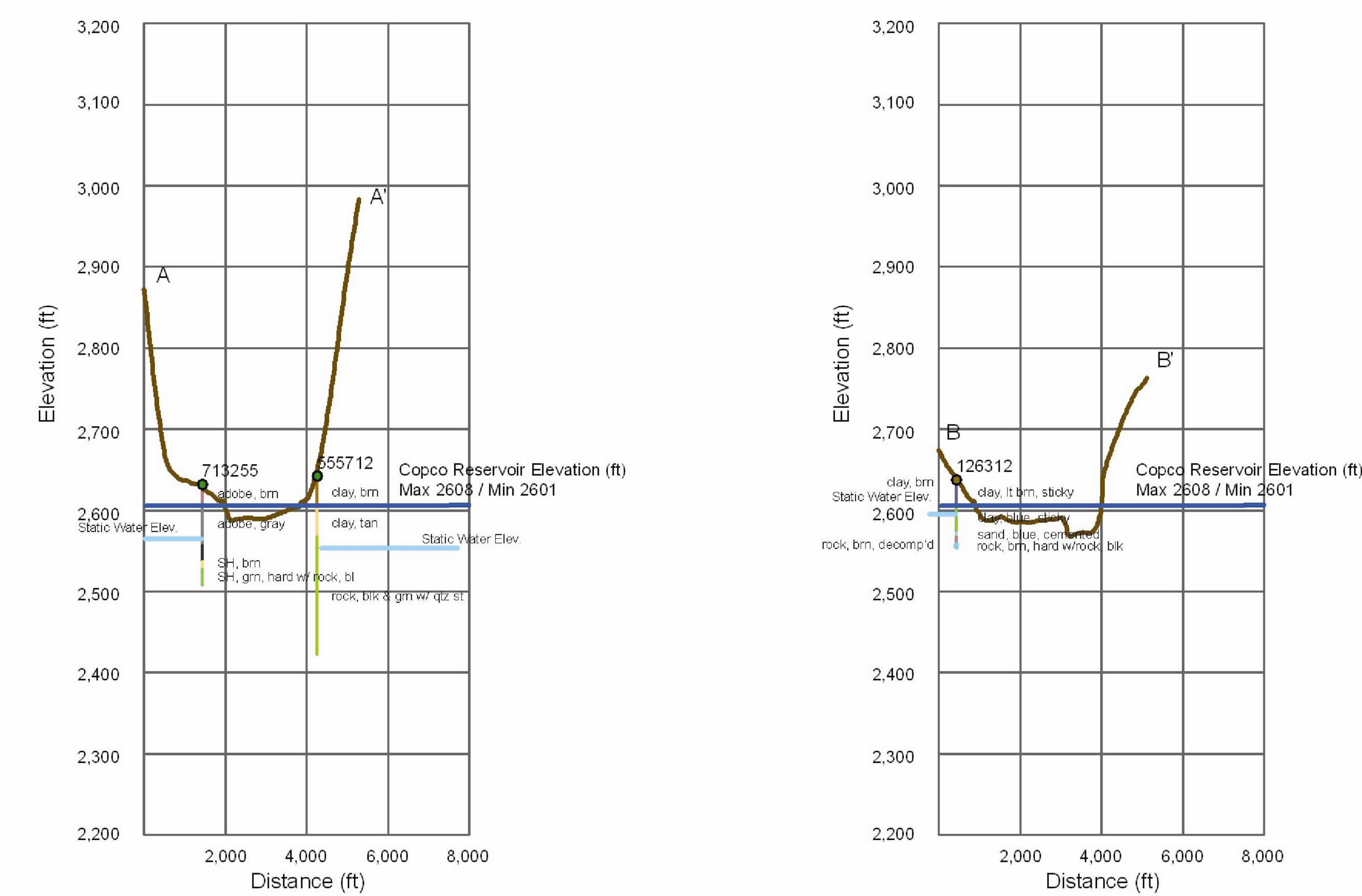
W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure K-1_Locatable Wells within 2.5 Miles of Copco Reservoir and Cross-Section Locations.ai 07/28/11 JJT

Figure K-1. Locatable Wells within 2.5 Miles of Copco Reservoir and Cross-Section Locations

Table K-4. Well Construction Information for Wells within 2.5 Miles of Copco Reservoirs[1]

Well ID[2]	Drill Date	Well Diameter (in)	Depth to top of perforated zone or bottom of surface casing in an open well (ft)	Depth to bottom of perforated zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-Section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
93347	8/5/1975	6	45 [3]	Open	110	N/R	20	15	D	N/R	Rock, 45 to 110 ft bgs; Elevation 2,608
126312	7/14/1976	6.625	63	83	83	55	10	40	B	2,597	Tight blue cemented sand, 55 to 70 ft bgs; Brown decomposed rock, 70 to 80 ft bgs; Elevation 2.582
512954	10/14/1998	6	75	225	384	N/R	2	50	C	2,566	Reddish tan rock, lighter tan rock, white rock, reddish tan rock; Elevation 2,541
555712	9/30/1994	6	100	120	220	N/R	15	80	A	2,597	Black/green rock w/quartz stringers, 100 to 120 ft bgs; Elevation 2,544
713255	7/19/1999	6	104 [3]	Open	124	N/R	30	60	A	2,565	Hard green and black rock, 104 to 124 ft bgs; Elevation 2,521
113378	08/01/1965	8	16	75	75	49	25	40	M	2,597	Small boulders, 49 to 60 ft bgs; Elevation 2,588
70943	06/20/1964	4.5	70	84	90	32	N/R	15	M	2,608	Gravel, 32 to 33 ft bgs; Elevation 2,591

Source: Adapted from DOI 2011.
Notes:
[1]Reservoir stage is 2,602 ft AMSL; river bed elevation at the dam is 2,493 ft AMSL.
[2]All wells listed as domestic supply wells.
[3]Depth to the bottom of the surface casing or sanitary seal in holes/wells that are open
Key:
AMSL: above mean sea level
bgs: below ground surface
in: inches
ft: feet
gpm: gallons per minute
N/R: Data not recorded



Cross-Section A-A'

Cross-Section B-B'

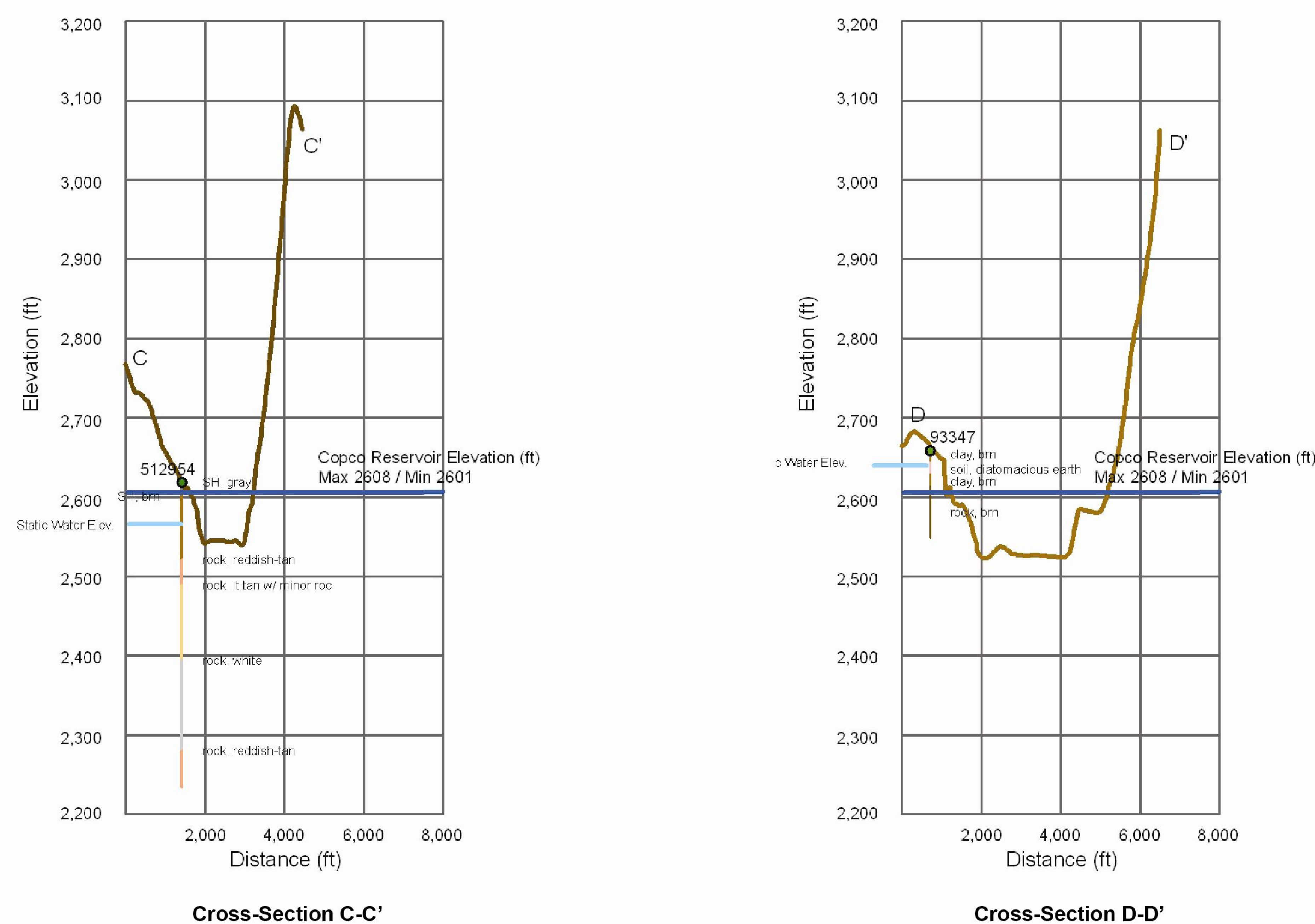
Abbreviations:

Materials		**Colors**		**Others**		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure K-2_Copco Reservoir Cross Sections A-A and B-B.ai 07/28/11 JJT

Figure K-2. Copco Reservoir Cross-Sections A and B

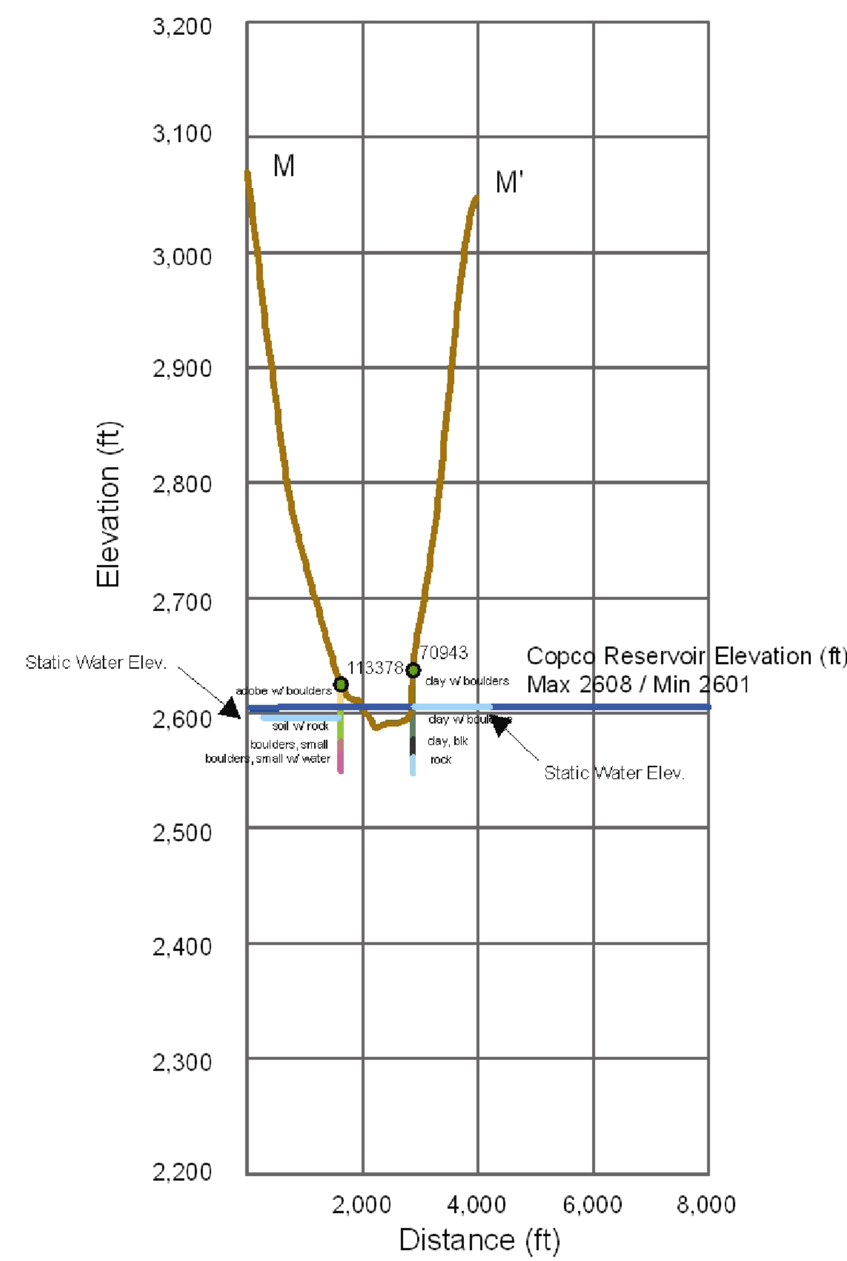


Abbreviations:

Materials		Colors		Others		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

Figure K-3. Copco Reservoir Cross-Sections C and D



Cross-Section M-M'

Abbreviations:

Materials		**Colors**		**Others**		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

Figure K-4. Copco Reservoir Cross-Section M

Iron Gate Reservoir

Table K-5. Well Construction information for Wells Identified within 2.5 Miles of Iron Gate Reservoir.

Well ID	311084	14918	78652	4355	334387	184187	311078	333890	99852	1087529	781723	369526	414209	99834	1075044	781725	781726	1075458	1087565	134222	134223	134224	14912	14911	958105
Ground Surface Elev (ft)	2712.9	2329.4	2409	2467.7	2508.8	2712.9	2465.9	2371.7	2712.9	2712.8	2171	2571.2	2624.8	2323.7	2815.2	2696.6	2460.8	2672.5	2696.1	2481.5	2481.5	2481.5	2389.6	2389.6	2767.5
Nearest Reservoir	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate	Iron Gate
Dist. To Reservoir (ft)	544.6	554.5	620.1	712	866.2	987.6	1095.9	1683.2	1735.6	2073.6	3025.1	3376.1	3507.4	3776.4	5049.5	5262.7	5331.6	5479.3	6942.6	7585.7	8199.2	8271.4	8904.6	9649.4	10499.2
Reservoir Elev. (ft)	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328
Reservoir Bed, Upstream End(ft)	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320
Reservoir Bed, Down\stream End(ft)	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165
Top of Perforated Interval, Depth (ft bgs)	20	40	80	20	25	271	22	23	20	100	35	25		20	52	54	55	40	140	120	20	80	40	100	30
Top of Perforated Interval, Elev. (ft)	2692.9	2289.4	2329	2447.7	2483.8	2441.9	2443.9	2348.7	2692.9	2612.8	2136	2546.2		2303.7	2763.2	2642.6	2405.8	2632.5	2556.1	2361.5	2461.5	2401.5	2349.6	2289.6	2737.5
Bottom of Perforated Interval, Depth (ft bgs)	270	160	140	70	420	291	246	271	500	200	90	200		200	260	265	530	125	300	160	530	120	60	120	247
Bottom of Perforated Interval, Elev. (ft)	2442.9	2169.4	2269	2397.7	2088.8	2421.9	2219.9	2100.7	2212.9	2512.8	2081	2371.2		2123.7	2555.2	2431.6	1930.8	2547.5	2396.1	2321.5	1951.5	2361.5	2329.6	2269.6	2520.5
Depth (ft bgs)	270	160	140	100	420	291	246	271	500	200	90	200		200	268	275	625	125	300	160	530	120	60	120	250
Well Bottom Elev. (ft)	2442.9	2169.4	2269	2367.7	2088.8	2421.9	2219.9	2100.7	2212.9	2512.8	2081	2371.2	2624.8	2123.7	2547.2	2421.6	1835.8	2547.5	2396.1	2321.5	1951.5	2361.5	2329.6	2269.6	2517.5
1st Water, Depth (ft bgs)	168	20	25	30		50	128	46	191	180	62	105		25	185	120	180	65	120	100		80	25	60	140
1st Water Elev (ft)	2544.9	2309.4	2384	2437.7		2662.9	2337.9	2325.7	2521.9	2532.8	2109	2466.2		2298.7	2630.2	2576.6	2280.8	2607.5	2576.1	2381.5		2401.5	2364.6	2329.6	2627.5
Water Bearing Zone, Depth (ft bgs)	250	20	25	50		280	128	210			35	105		156	185	120	180	65	140	100		80	25	60	140
Water Bearing Zone, Elev. (ft)	2462.9	2309.4	2384	2417.7		2432.9	2337.9	2161.7			2136	2466.2		2167.7	2630.2	2576.6	2280.8	2607.5	2556.1	2381.5		2401.5	2364.6	2329.6	2627.5
Pumping Rate (GPM)	25	40	6	10	0.1	15	12	12	5	25	75	20		25	30	7	12	100	20	20	1	15	50	50	
Static Water Level, Depth (ft bgs)		-5	25	50	290				150		30	30		10	30	52	130	35	120	50	60	30	10	28	-5
Static Water Level, Elev. (ft bgs)		2334.4	2384	2417.7	2218.8				2562.9		2141	2541.2		2313.7	2785.2	2644.6	2330.8	2637.5	2576.1	2431.5	2421.5	2451.5	2379.6	2361.6	2772.5

Table K-5. Well Construction information for Wells Identified within 2.5 Miles of Iron Gate Reservoir.

Well ID	311084	14918	78652	4355	334387	184187	311078	333890	99852	1087529	781723	369526	414209	99834	1075044	781725	781726	1075458	1087565	134222	134223	134224	14912	14911	958105
Unit 1	0 to 32 ft bgs; rock-dirt	0 to 20 ft bgs; clay, brn, rocky	0 to 20 ft bgs; clay, brn w/ rock	0 to 2 ft bgs; hardpan	0 to 350 ft bgs; N/R	0 to 45 ft bgs; topsoil, clays into lava, lt gray	0 to 25 ft bgs; clay, adobe	0 to 23 ft bgs; clay, red	0 to 1 ft bgs; soil, brn	0 to 160 ft bgs; clay, adobe	0 to 3 ft bgs; clay, blk	0 to 2 ft bgs; clay, blk	N/R	0 to 1 ft bgs; soil, brn	0 to 2 ft bgs; clay, blk w/ cobbles	0 to 4 ft bgs; clay, blk	0 to 1 ft bgs; clay, blk	0 to 9 ft bgs; clay, blk	0 to 4 ft bgs; topsoil	0 to 10 ft bgs; clay, brn	0 to 10 ft bgs; clay, brn	0 to 5 ft bgs; clay, brn	0 to 20 ft bgs; clay, brn w/ gravel	0 to 20 ft bgs; clay, brn w/ rock	0 to 2 ft bgs; soil, brn
Unit 2	32 to 106 ft bgs; clay, gray w/ rock, brn	20 to 40 ft bgs; rock, brn, soft w/ water	20 to 40 ft bgs; rock, brn, soft	2 to 30 ft bgs; adobe, gray	350 to 395 ft bgs; CLST, blue	45 to 281 ft bgs; lava, lt gray w/ clay, gray & blue	25 to 46 ft bgs; clay, lt brn, sticky	23 to 46 ft bgs; clay, gray	1 to 12 ft bgs; clay, brn	160 to 200 ft bgs; rock, brn	3 to 18 ft bgs; clay, brn	2 to 12 ft bgs; clay, brn		1 to 16 ft bgs; clay, brn	2 to 18 ft bgs; clay, brn	4 to 20 ft bgs; clay, brn	1 to 30 ft bgs; clay, brn	9 to 38 ft bgs; SDST, brn	4 to 20 ft bgs; clay	10 to 40 ft bgs; rock, brn, soft	10 to 40 ft bgs; rock, brn, soft	5 to 20 ft bgs; rock, red, soft	20 to 60 ft bgs; rock, blk w/ water	20 to 40 ft bgs; rock, lt gray	2 to 17 ft bgs; boulders
Unit 3	106 to 168 ft bgs; clay, gray w/ rock, brn	40 to 100 ft bgs; rock, grn, hard	40 to 50 ft bgs; rock, gray	30 to 70 ft bgs; gravel, volcanic	395 to 420 ft bgs; lava ash, red	291 to 291 ft bgs; lava, lt gray	46 to 87 ft bgs; rock w/ clay, gray	46 to 148 ft bgs; clay, redish-brn w/ water	12 to 26 ft bgs; CLST, brn		18 to 24 ft bgs; sand & boulders	12 to 35 ft bgs; CLST, red		16 to 37 ft bgs; basalt, brn, broken w/ water	18 to 28 ft bgs; ash,red	20 to 46 ft bgs; CLST, red	30 to 120 ft bgs; SDST, blue, hard	38 to 55 ft bgs; basalt, blue, hard	20 to 120 ft bgs; SH, gray	40 to 140 ft bgs; rock, gray	40 to 95 ft bgs; clay, red, hard	20 to 40 ft bgs; rock, brn, soft		40 to 80 ft bgs; rock, gray w/ water	17 to 18 ft bgs; clay, brn
Unit 4	168 to 209 ft bgs; rock, brn-gray	100 to 140 ft bgs; rock, gray	50 to 60 ft bgs; rock, brn	70 to 100 ft bgs; gravel, volcanic w/ clay			87 to 128 ft bgs; clay, reddish-gray	148 to 210 ft bgs; gravel, brn w/ water	26 to 160 ft bgs; SDST, blue		24 to 30 ft bgs; SDST, brn	35 to 105 ft bgs; CLST, blue		37 to 100 ft bgs; basalt, blue	28 to 45 ft bgs; rock, brn, soft	46 to 85 ft bgs; SPTN, blue, hard	120 to 150 ft bgs; CLST, blue	55 to 60 ft bgs; CLST, purple	120 to 260 ft bgs; SH, dk gray	140 to 160 ft bgs; rock, gray,hard	95 to 120 ft bgs; rock, blk	40 to 120 ft bgs; rock, brn w/ water		80 to 120 ft bgs; rock, blk	18 to 27 ft bgs; rock, blue, broken
Unit 5	209 to 229 ft bgs; rock, brn	140 to 160 ft bgs; rock, grn	60 to 70 ft bgs; rock, gray				128 to 246 ft bgs; clay, grayish-brn	210 to 271 ft bgs; rock, gray to brnsh-gray w/ water	160 to 195 ft bgs; CLST, red		30 to 62 ft bgs; SPTN, blue	105 to 108 ft bgs; CLST, red, broken w/ water		100 to 112 ft bgs; CLST, purple	45 to 120 ft bgs; rock, blue, hard	85 to 120 ft bgs; ash, red	150 to 180 ft bgs; SDST, blue	60 to 65 ft bgs; basalt, blue	260 to 300 ft bgs; SH, gray, fract'd		120 to 530 ft bgs; rock, dk brn				27 to 140 ft bgs; rock, gray, hard
Unit 6	229 to 270 ft bgs; rock, brnsh-gray w/water		70 to 140 ft bgs; rock, brn						195 to 250 ft bgs; SDST, blue		62 to 63 ft bgs; SPTN, blue w/ qtz w/ water	108 to 170 ft bgs; CLST, red		112 to 156 ft bgs; basalt, blue	120 to 185 ft bgs; rock, blue	120 to 121 ft bgs; SPTN, blue w/ qtz w/ water	180 to 182 ft bgs; SDST, blue, fract'd w/ water	65 to 78 ft bgs; basalt, blue, fract'd w/ qtz w/ water							140 to 141 ft bgs; rock, gray, fract'd w/ water
Unit 7									250 to 268 ft bgs; CLST, red		63 to 90 ft bgs; SPTN, blue	170 to 175 ft bgs; CLST, blue, broken w/ water		156 to 157 ft bgs; basalt, blue, broken w/ water	185 to 186 ft bgs; rock, blue, fract'd w/w water	121 to 160 ft bgs; SPTN, blue, hard	182 to 360 ft bgs; SDST,blue	78 to 107 ft bgs; basalt, blue, hard							141 to 180 ft bgs; rock, gray, hard
Unit 8									268 to 290 ft bgs; SDST, blue			175 to 200 ft bgs; SDST, blue		157 to 180 ft bgs; basalt, blue	186 to 240 ft bgs; rock, blue, hard	160 to 220 ft bgs; ash, red	360 to 361 ft bgs; SDST, blue, fract'd w/ water	107 to 110 ft bgs; basalt, blue, fract'd w/ water							180 to 200 ft bgs; rock, red, hard
Unit 9									290 to 291 ft bgs; SDST, blue, broken					180 to 182 ft bgs; basalt, blue, broken w/ water	240 to 242 ft bgs; rock, blue, fract'd w/w water	220 to 235 ft bgs; SPTN,blue, hard	361 to 410 ft bgs; SDST, blue	110 to 118 ft bgs; basalt, blue, hard							200 to 210 ft bgs; rock, gray, hard

Table K-5. Well Construction information for Wells Identified within 2.5 Miles of Iron Gate Reservoir.

Well ID	311084	14918	78652	4355	334387	184187	311078	333890	99852	1087529	781723	369526	414209	99834	1075044	781725	781726	1075458	1087565	134222	134223	134224	14912	14911	958105
Unit 10									291 to 312 ft bgs; CLST, red					182 to 200 ft bgs; basalt, blue	242 to 268 ft bgs; rock, blue, hard	235 to 236 ft bgs; SPTN, blue, fract'd w/ water	410 to 430 ft bgs; basalt, blue	118 to 125 ft bgs; CLST, purple							210 to 211 ft bgs; rock, gray, fract'd w/ water
Unit 11									312 to 367 ft bgs; SDST, grn							236 to 275 ft bgs; SPTN,blue, hard	430 to 431 ft bgs; basalt, blue, fract'd w/ water								211 to 250 ft bgs; rock, gray, hard
Unit 12									367 to 382 ft bgs; CLST, red								431 to 530 ft bgs; basalt, blue								
Unit 13									382 to 383 ft bgs; SDST, blue, broken								530 to 625 ft bgs; ash, red, caving								
Unit 14									383 to 448 ft bgs; CLST, blue																

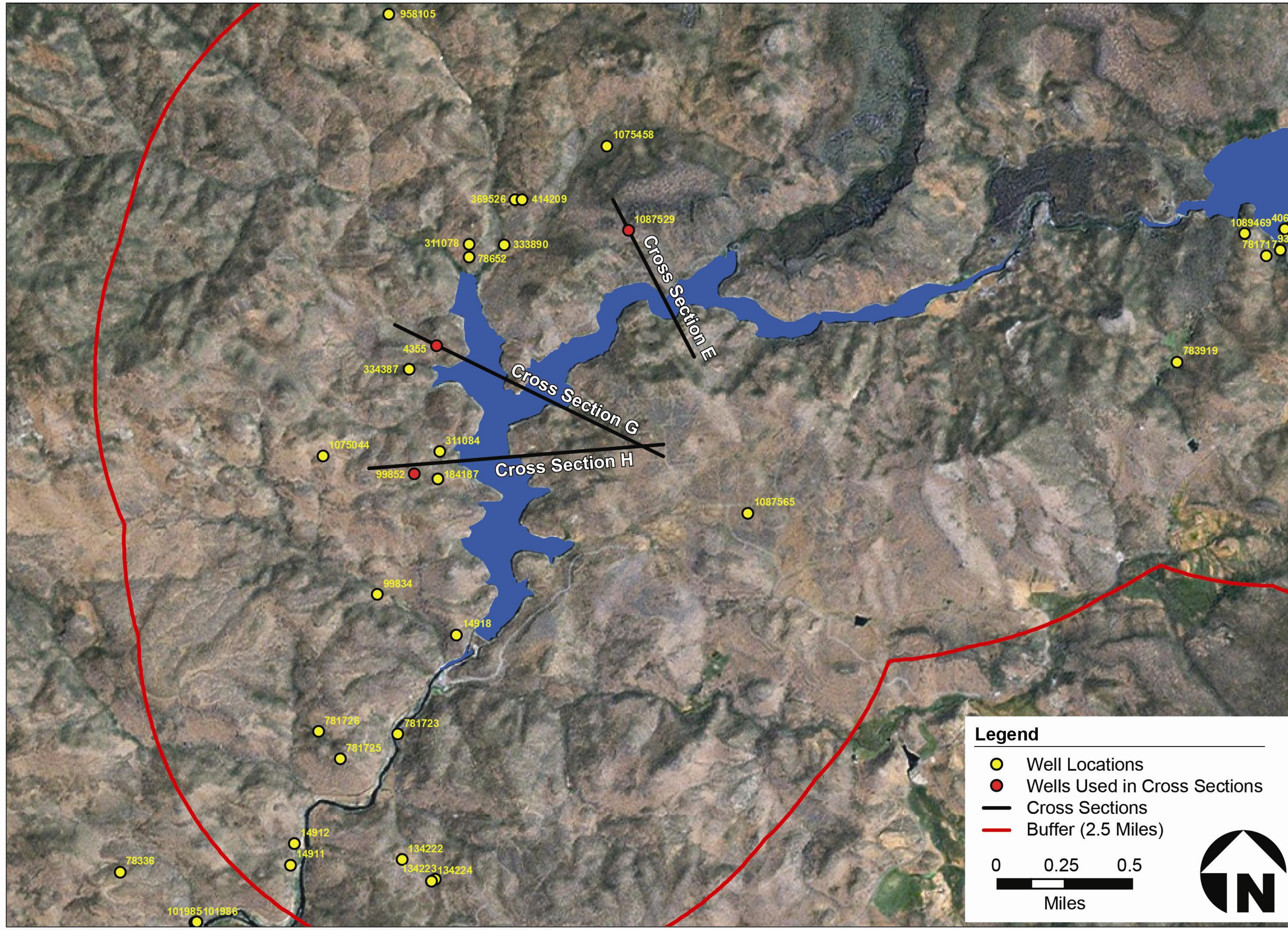


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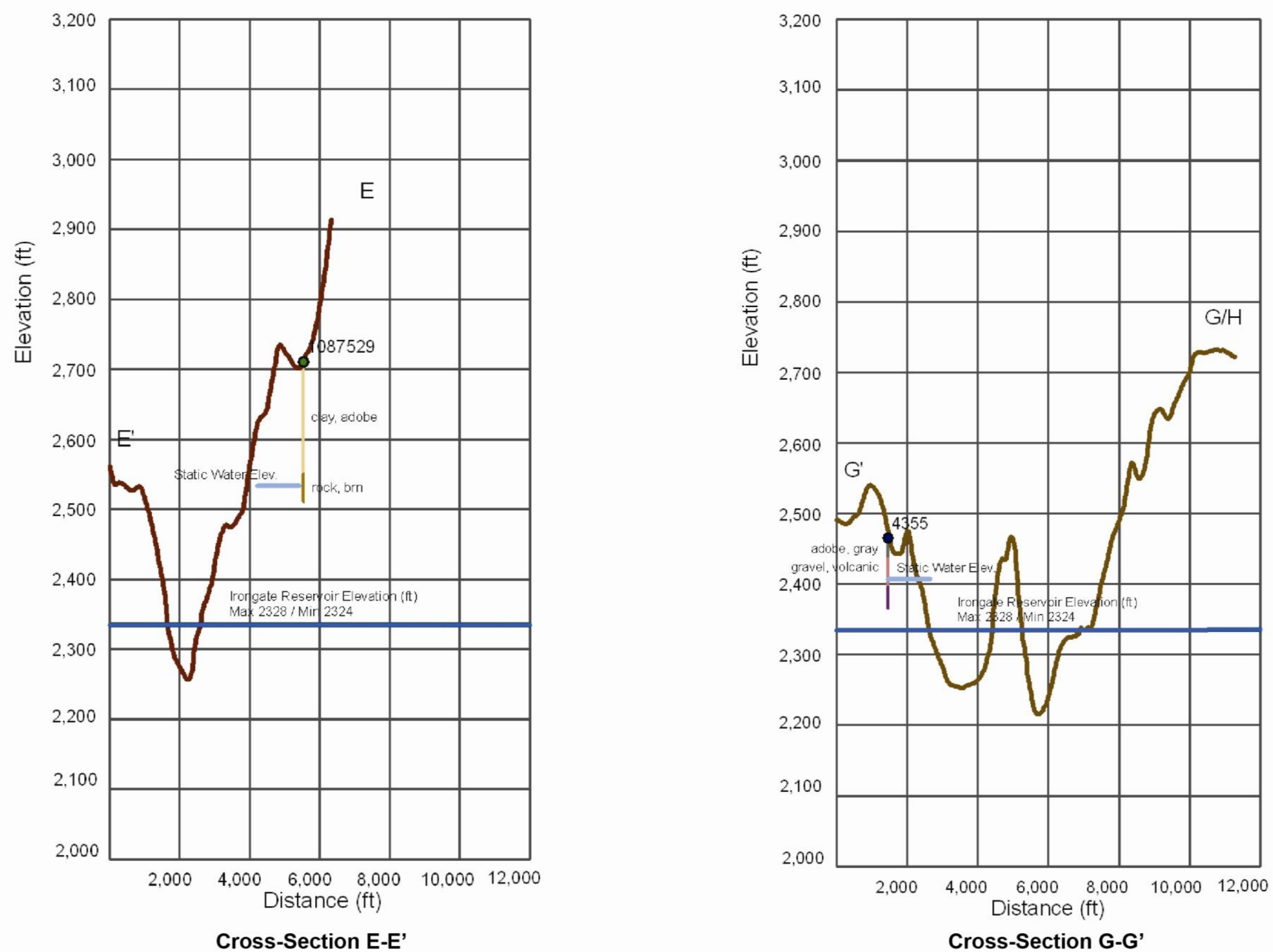
Figure K-5. Locatable Wells within 2.5 Miles of Iron Gate Reservoir and Cross-Section Locations

Table K-6. Well Construction Information for Wells within 2.5 Miles of Iron Gate Reservoir

Well ID[2]	Drill Date	Well Diameter (in)	Depth to top of perforated zone or bottom of surface casing in an open well[3] (ft)	Depth to bottom of perforated zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-Section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
4355	6/14/1966	8	12	70	100	30	10	50	G	2,424	Volcanic gravels, 30 to 700 ft bgs; Elevation 2,444
99852	9/1/1981	6.625	30	Open	500	191	5	150	H	2,563	Blue sandstone from 195 to 250 ft bgs; Elevation 2,518
1087529	5/1/2004	8	100	200	200	180	25	N/R	E	N/R	Brown rock, 160 to 200 ft bgs; Elevation 2, 532

Source: Adapted from DOI 2011.
Notes:
[1]Reservoir stage is 2,328 ft AMSL; river bed elevation at the dam is 2,165 ft AMSL.
[2]Wells 24272 and 29830 are domestic supply wells. Well 1087529 is listed as an domestic/irrigation well.
[3]Depth to the bottom of the surface casing or sanitary seal in holes/wells that are open
Key:
AMSL: above mean sea level
bgs: below ground surface
in: inches
ft: feet
gpm: gallons per minute
N/R: Data not recorded



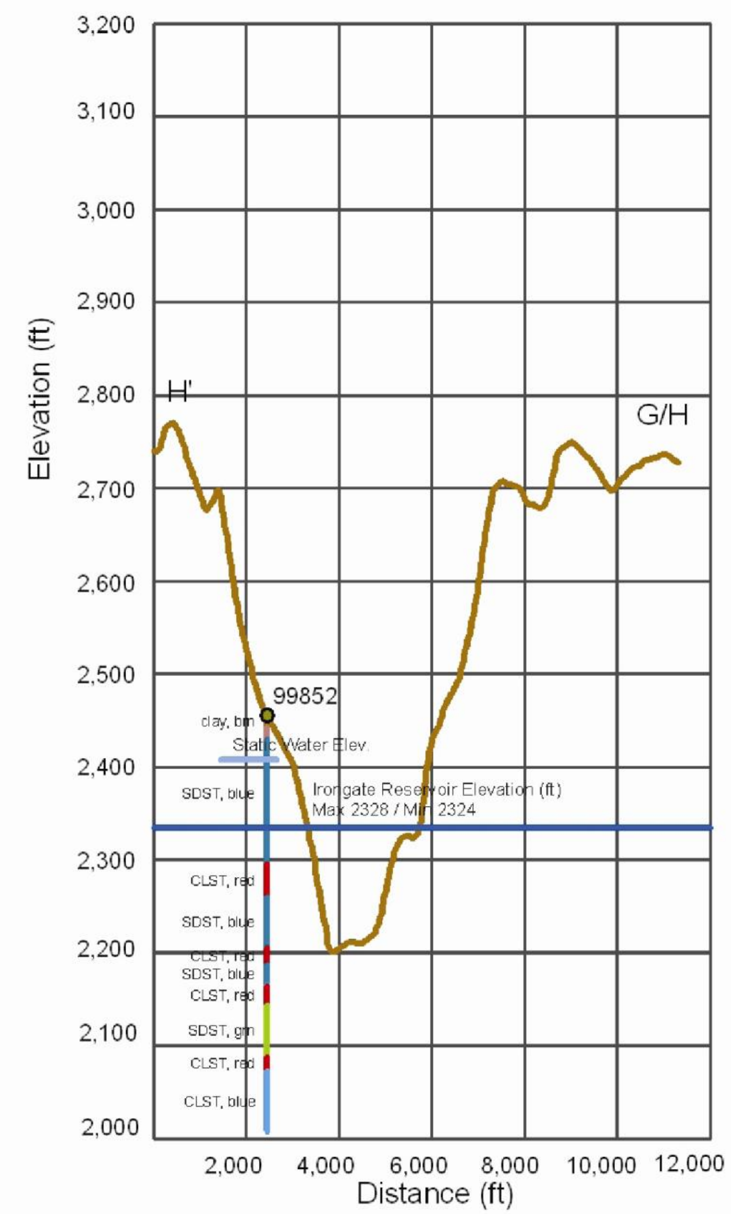
Abbreviations:

Materials		Colors		Others		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure K-6_Iron Gate Reservoir Cross Sections E-E and G-G.ai 07/28/11 JJT

Figure K-6. Iron Gate Reservoir Cross-Sections E and G



Cross-Section H-H'

Abbreviations:

Materials		Colors		Others		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure K-7_Iron Gate Reservoir Cross Section H-H.ai 07/28/11 JJT

Figure K-7. Iron Gate Reservoir Cross-Section H

K.1 References

Department of the Interior (DOI), Bureau of Reclamation. 2011. "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration". Prepared for Mid-Pacific Region, U.S. DOI, Bureau of Reclamation, Technical Service Center, Denver, CO. April 2011.

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Appendix L
Water Rights

Upstream of Iron Gate Dam, the mainstem of the Klamath River is controlled by several dams operated by PacifiCorp for hydropower generation. Downstream of Iron Gate Dam, the mainstem of the Klamath River flows freely 190 miles through Siskiyou, Del Norte, and Humboldt Counties to the Pacific Ocean. A query on California's Electronic Water Rights Information Management System provided 6 water rights listings upstream of Iron Gate Dam and 32 water right listings downstream of Iron Gate Dam with the Klamath River or Klamath River reservoir as the water source. This appendix contains the query results and has a map that displays the locations.

Table L-1. Water Rights on Klamath River: Upstream of Iron Gate Dam

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
Downstream of CA/OR Border										
	S015377			7/10/2022	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	2,200 acre-feet per year to irrigate 43 acres and stock watering between April and October.
	S015378			7/10/2022	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	575 acre-feet per year to irrigate 8 acres and stock watering between April and October.
	S015737			4/28/2003	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	2,700 acre-feet per year to irrigate 58.3 acres and stock watering between April and October.
Copco Lake										
	S015374			2/19/2002	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	Water is stored in Copco Lake. Average use approximately 1,000 to 1,200 cfs per month for impoundment of water and generation of electric power, non-consumptive use. FERC license #2082. In conjunction with S013375.
	S015375			2/25/2002	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	Average diversion of approximately 1,400 to 1,900 cfs per month for hydropower and impoundment at Copco 1 Powerhouse, non-consumptive use and Copco Lake. In conjunction with S015364.

Table L-1. Water Rights on Klamath River: Upstream of Iron Gate Dam

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
	S015376			2/19/2002	Statement of Div and Use	Claimed	PacifiCorp	Government (State/Municipal)	Siskiyou	Average diversion of approximately 1,300 to 1,900 cfs per month for hydropower and impoundment at Copco 2 Powerhouse and Copco Lake.

Source: California Electronic Water Rights Information Management System (SWRCB 2010)

Notes:

[1]Status Definitions:

Claimed: Riparian and pre-1914 appropriative rights predate the Water Commission act. Entities that hold these rights are not required to obtain a permit from the SWRCB. These types of rights can only be confirmed by the courts.

[2]cfs = cubic feet per second, gpm = gallons per minute, gpd = gallons per day

Table L-2. Water Rights on Klamath River: Iron Gate Dam and Downstream Reach

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
Iron Gate Dam										
WR-1	A017527	12259	9457	3/26/1957	Appropriative	Licensed	PacifiCorp	Government (State/Municipal)	Siskiyou	1,800 cfs for power generation, 50 cfs for fish propagation facilities, 3,300 cfs to refill regulatory storage space in Iron Gate Reservoir. Direct diversion amount not to exceed 3,300 cfs. Permit for January 1–December 31. Other previsions include maximum diversion not to exceed 120,000 acre-feet in a water year, maximum flow rate not to exceed 300 cfs May 16–September 15, and not to exceed 100 cfs September 16–May 15.
WR-2	A016957			3/20/1956	Appropriative	State Filing	SWRCB (State Water Resources Control Board)	Government (State/Municipal)	Siskiyou	Diversion storage amount 60,000 acre-feet
WR-3	A016958			3/20/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Siskiyou	Diversion storage amount 60,000 acre-feet
WR-4	S012968			3/30/1987	Statement of Div and Use	Claimed	PacifiCorp	Corporation	Siskiyou	Direct diversion amount 48 cfs
WR-5	A019478	12741	7715	6/6/1960	Appropriative	Licensed	Klamath River Country Estates Owners Association Inc	Government (State/Municipal)	Siskiyou	Direct diversion amount 0.1 cfs, May 1–October 31 for irrigation of 8 acres. Can increase diversion rate, but must not interfere with other vested water rights or go over flow allowance in a 30-day period.
WR-6	S016524			12/10/2010	Statement of Div and Use	Claimed	R- Ranch Poa	Corporation	Siskiyou	Direct diversion amount 126.8 acre-feet per year

Table L-2. Water Rights on Klamath River: Iron Gate Dam and Downstream Reach

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
WR-7	S000708			5/22/1967	Statement of Div and Use	Claimed	Klamath River Country Estates Owners Association Inc	Corporation	Siskiyou	Irrigation of 8 acres. The Statement of Water Diversion and Use includes use during May 1–October 31; maximum flow rate of 25 gallons per minute (gpm) but flow volume used per month changes. There is an approximate total use of 1.6 million gallons annually.
WR-8	D031134R		000568R	6/30/2006	Small Domestic Reg	Registered	Richard K Kleinkopf	Individual	Siskiyou	Direct diversion amount shall not exceed 4,500 gallons per day (gpd) during January 1–December 31 for domestic use. Max diversion not to exceed 5 acre-feet per year.
WR-9	S011340			4/30/2007	Statement of Div and Use	Inactive			Siskiyou	Direct diversion amount 9,000 gpd, no name of file since 2007.
WR-10	A022434	15179	9480	3/29/1966	Appropriative	Licensed	Deanne Starritt	Individual	Siskiyou	Direct diversion amount 10,000 gpd, April 1–October 1 for irrigation of 3 acres and fire protection. Max diverted is 2.5 acre-feet per year. Can increase diversion rate, but must not interfere with other vested water rights or go over flow allowance in a 30-day period.
WR-11	S001040			7/31/2008	Statement of Div and Use	Inactive	Edwin M Roston	Individual	Siskiyou	Direct diversion amount 8.9 cfs
WR-12	S009616			5/19/2008	Statement of Div and Use	Inactive	E M Roston & Sons	Corporation	Siskiyou	Direct diversion amount 1.1 cfs
WR-13	S009617			5/19/2008	Statement of Div and Use	Inactive	E M Roston & Sons	Corporation	Siskiyou	Direct diversion amount 3.56 cfs, no updated address on file, status is inactive.

Table L-2. Water Rights on Klamath River: Iron Gate Dam and Downstream Reach

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
WR-14	S009618			5/19/2008	Statement of Div and Use	Inactive	E M Roston & Sons	Corporation	Siskiyou	Direct diversion amount 0.45 cfs, no updated address on file, status is inactive.
Downstream of Cottonwood Creek										
WR-15	S013204			8/1/2008	Statement of Div and Use	Inactive	Marie Dolores Jorgensen	Individual	Siskiyou	Direct diversion amount 0.134 cfs
WR-16	S014586			6/4/1996	Statement of Div and Use	Claimed	Robert P Fuhs	Individual	Siskiyou	Direct diversion amount 0.11 cfs, Diversion 1.4 acre-feet
WR-17	S014788			1/16/1998	Statement of Div and Use	Claimed	Richard L Jennings	Individual	Siskiyou	Direct diversion amount 1.1 cfs, Diversion 1,000 acre-feet
WR-18	S016753			6/23/2010	Statement of Div and Use	Claimed	Matthew J Connelly	Individual	Siskiyou	Direct diversion amount 0 acre-feet/yr
WR-19	S013405			5/10/1990	Statement of Div and Use	Claimed	The Rea Family Trust	Corporation	Siskiyou	Direct diversion amount 14,400 gpd
WR-20	S010021			1/21/1980	Statement of Div and Use	Claimed	Steven G. Moore	Individual	Siskiyou	Direct diversion amount 100 gpd for irrigation and stock watering.
WR-21	S013406			5/10/1990	Statement of Div and Use	Claimed	Carlos Zepeda	Individual	Siskiyou	Direct diversion amount 7,200 gpd
WR-22	S014172			4/11/1994	Statement of Div and Use	Claimed	Robert Rainey	Individual	Siskiyou	Direct diversion amount 0.33 cfs, Diversion 30 acre-feet
WR-23	A017036			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Siskiyou	Diversion storage amount 1,850,000 acre-feet
WR-24	A017035			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Siskiyou	Diversion storage amount 1,850,000 acre-feet
Downstream of Happy Camp and Seiad Valley										
WR-25	A017034			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Siskiyou	Diversion storage amount 1,850,000 acre-feet
WR-26	A017033			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Siskiyou	Diversion storage amount 4,120,000 acre-feet

Table L-2. Water Rights on Klamath River: Iron Gate Dam and Downstream Reach

General Location/Map ID	Application ID	Permit ID	License ID	Date	Water Right Type	Status[1]	Holder Name	Organization Type	County	Additional Information[2]
WR-27	A021640	14454	10072	2/10/1964	Appropriative	Licensed	Leo A Mollier	Individual	Humboldt	Direct diversion amount 0.13 cfs, max 0.15 cfs as long as not to exceed 7.8 acre-feet in 30 days. Maximum amount allowed in a year 39 acre-feet. Use is for irrigation purposes for 19 acres; use May 1–December 1.
WR-28	A017032			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Humboldt	Diversion storage amount 5,480,000 acre-feet
WR-29	A017031			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Humboldt	Diversion storage amount 5,480,000 acre-feet
WR-30	A017038			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Humboldt	Diversion storage amount 1,940,000 acre-feet
WR-31	A017037			4/24/1956	Appropriative	State Filing	SWRCB	Government (State/Municipal)	Humboldt	Diversion storage amount 1,940,000 acre-feet
WR-32	A023121	15791		8/29/1968	Appropriative	Permitted	Klamath Community Services District	Government (State/Municipal)	Del Norte	Direct diversion amount 0.5 cfs, Diversion 210 acre-feet per year
Pacific Ocean										

Source: California Electronic Water Rights Information Management System (SWRCB 2010)

Notes:

[1]Status Definitions:

Claimed: Riparian and pre-1914 appropriative rights predate the Water Commission act. Entities that hold these rights are not required to obtain a permit from the SWRCB. These types of rights can only be confirmed by the courts.

Permitted: A permit is an authorization that allows for the development of a project to proceed with considerations for the beneficial uses of water, the public interest, reasonableness, and the public trust.

Licensed: If a project is determined to be using the allotted water beneficially under the conditions of a permit, a vested water right license is issued.

Registered: In lieu of a water right, entities can register to divert and use a small amount of water from a stream for domestic purposes or the use of a small amount of water for livestock. In such cases, the use is registered with the SWRCB and must follow conditions set by the CDFG to protect fish and wildlife.

Inactive: Unexercised water right.

Revoked: Permits and licenses may be revoked if a water right is forfeited after five years of non-use or if a water right is abandoned.

State filing: To preserve water for future use and development consistent with a coordinated plan such as the State's Water Plan or a County General Plan. The SWRCB holds them in trust for the people of California. Parties who desire to develop water supply projects consistent with the coordinated plan may petition the SWRCB to assign all or part of the state-filed application to them. If approved, this action gives the petitioner a water right priority based on the date that the state-filed the water right application.

[2]cfs = cubic feet per second, gpm = gallons per minute, gpd = gallons per day

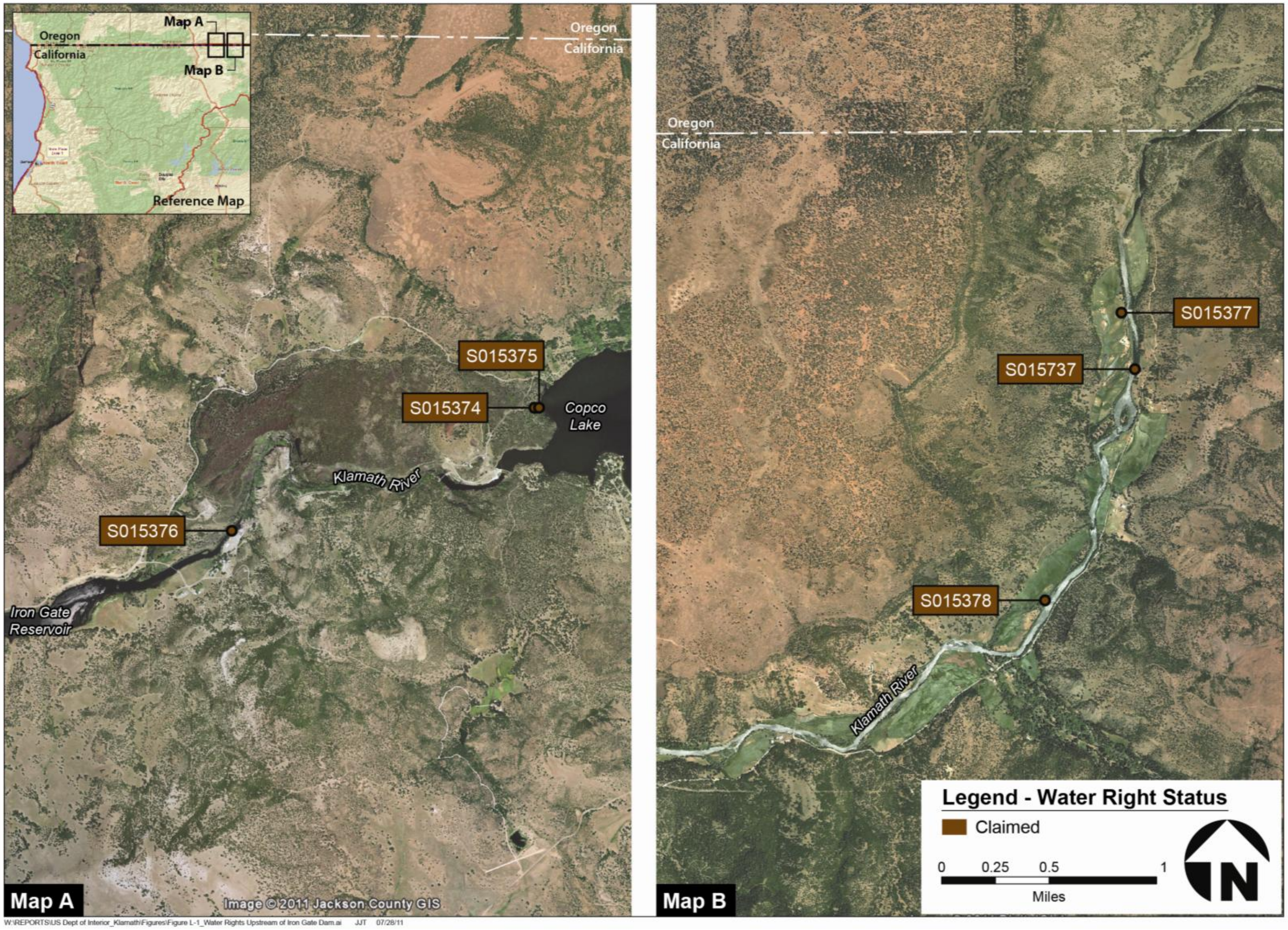


Figure L-1. Water Rights Upstream of Iron Gate Dam (IDs are referenced in Table L-1)

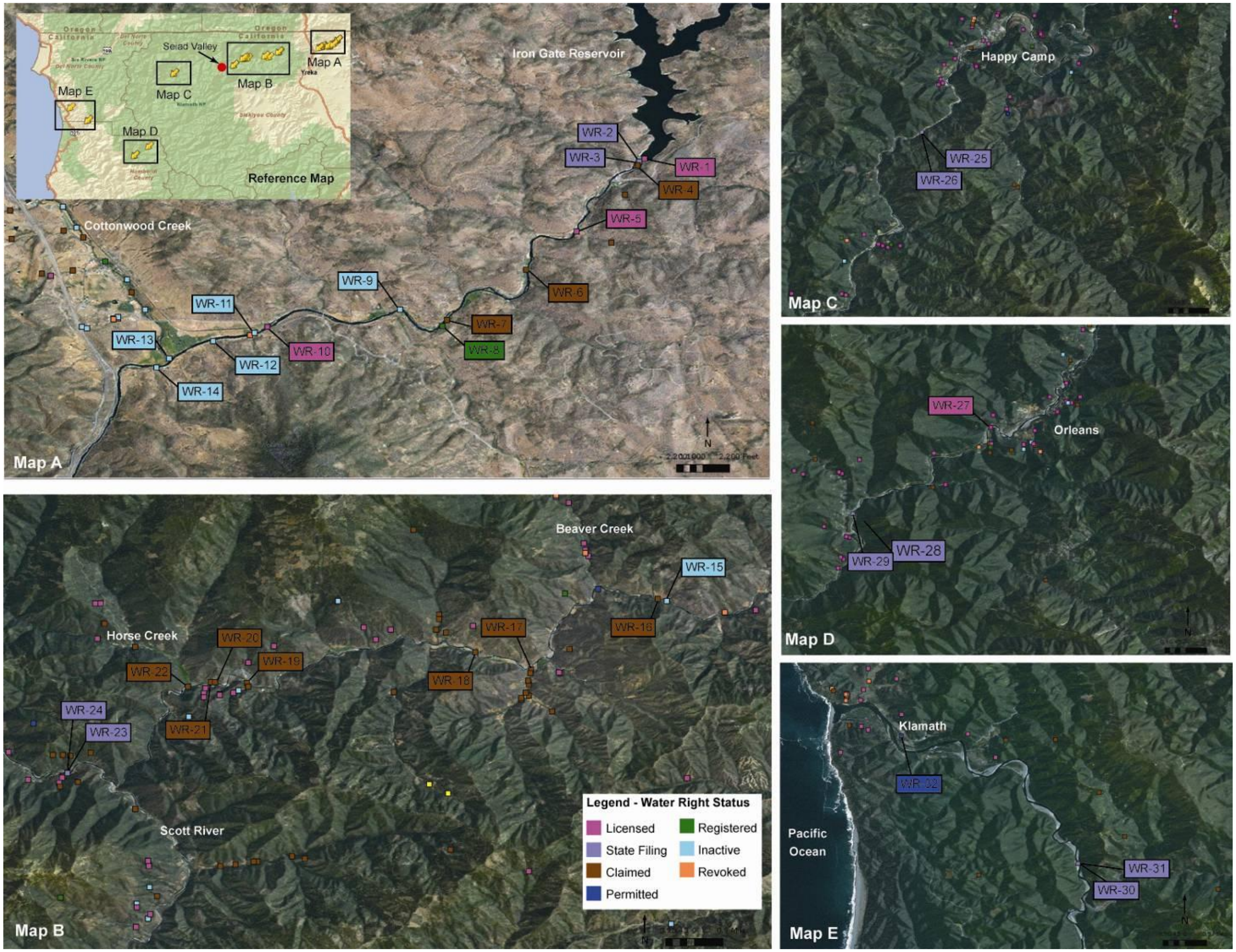


Figure L-2. Water Rights Downstream of Iron Gate Dam (IDs are referenced in Table L-2)

L.1 References

State Water Resource Control Board (SWRCB). 2010. California Electronic Water Rights Information Management System. Accessed at http://www.swrcb.ca.gov/ewrims/. Accessed on December 17, 2010 and July 8, 2011.

Appendix M
Air Quality Impacts

M.1 Existing Emission Sources and Monitoring Data

This section provides estimates of the existing emissions in Siskiyou, California and Klamath, Oregon Counties to identify the major sources of emissions. Existing monitoring data is also provided as context for the region's attainment status.

M.1.1 Emission Sources

Table M-1 presents estimates of existing emissions in Siskiyou County for 2008, the latest year for which an inventory is available. Miscellaneous area-wide processes are the major sources of volatile organic compounds (VOC), carbon monoxide (CO), sulfur oxides (SOx), inhalable particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$) emissions in Siskiyou County, while on-road motor vehicles are the major sources of nitrogen oxides (NOx) emissions. Managed burning and disposal is the major source of VOC, CO, PM_{10}, and $PM_{2.5}$ emissions within the area-wide sources, and residential fuel combustion is the major driver of NOx and SOx emissions within the area-wide sources.

Table M-1. Siskiyou County (California) 2008 Emission Inventories

Source Type	Category	Average Emissions in Tons per Year (TPY)					
		VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Stationary	Fuel Combustion	44	234	245	--	95	92
Stationary	Waste Disposal	--	4	--	--	--	--
Stationary	Cleaning and Surface Coatings	62	--	--	--	--	--
Stationary	Petroleum Production and Marketing	117	--	--	--	--	--
Stationary	Industrial Processes	59	--	--	--	128	59
Area	Solvent Evaporation	1,054	--	--	--	--	--
Area	Miscellaneous Processes	3,616	79,993	139	73	11,650	6,043
Mobile	On-Road Motor Vehicles	1,175	9,695	4,692	4	176	146
Mobile	Other Mobile Sources	893	3,693	1,746	7	95	81
Grand Totals		7,020	93,619	6,822	84	12,144	6,420

Source: California Air Resources Board (CARB) 2009.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Table M-2 presents estimates of existing emissions in Klamath County for 2002, the latest year in which an inventory is available. Highway and off-highway vehicles represent the majority of CO, NOx, and sulfur dioxide (SO_2) emissions. Fugitive dust, residential wood burning, and agricultural and forestry activities are the major sources of PM_{10} and $PM_{2.5}$ emissions. The major source of VOC emissions is residential wood burning, followed by highway and off-highway vehicles.

Table M-2. Klamath County (Oregon) 2002 Emission Inventories

Source Type	Category	Average Emissions in Tons per Year (TPY)					
		CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
Point	Fuel Combustion – Industrial	1,527	626	175	156	11	59
Nonpoint	Fuel Combustion – Industrial	2	14	2	1	49	--
Point	Fuel Combustion – Other	1	2	<1	<1	<1	<1
Nonpoint	Fuel Combustion – Other	9,161	219	1,303	1,303	63	3,248
Point	Other Industrial Processes	14	31	230	89	<1	1,552
Nonpoint	Chemical & Allied Product Mfg	--	--	--	--	--	1
Nonpoint	Other Industrial Processes	11	0	207	58	<1	3
Nonpoint	Solvent Utilization	--	--	--	--	--	2,037
Nonpoint	Storage and Transport	--	--	--	--	--	508
Nonpoint	Waste Disposal & Recycling	1,403	68	233	220	8	100
Nonpoint	Highway Vehicles	35,315	3,198	72	54	82	3,175
Nonpoint	Off-Highway	9,398	3,828	194	180	221	2,829
Nonpoint	Miscellaneous	--	129	7,830	759	--	--
Grand Totals		56,830	8,114	10,248	2,820	425	13,512

Source: United States Environmental Protection Agency (USEPA) 2010.
Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.1.2 Monitoring Data

Table M-3 summarizes the air quality data from monitoring stations near the area of analysis in California. Data from the Yreka monitoring station was used to characterize the ambient air quality near the California-based dams. Because the Yreka monitoring station only monitors for ozone (O_3), PM_{10}, and $PM_{2.5}$, other pollutants are not summarized in the table.

As Table M-3 shows, O_3 concentrations exceeded the California Ambient Air Quality Standards (CAAQS) and PM_{10} concentrations exceeded the National Ambient Air Quality Standards (NAAQS) during the past three years at the Yreka monitoring station. Area designations in California are applicable to the entire county; because the Yreka monitoring station is exceeding the CAAQS, the rest of the county is designated as a nonattainment area as well. As Figure M-1 shows, there is no clear trend in O_3 concentrations during the past three years; however, substantial year-to-year variations in O_3 concentrations are common.

Table M-3. Summary of Pollutant Monitoring Data in Siskiyou County

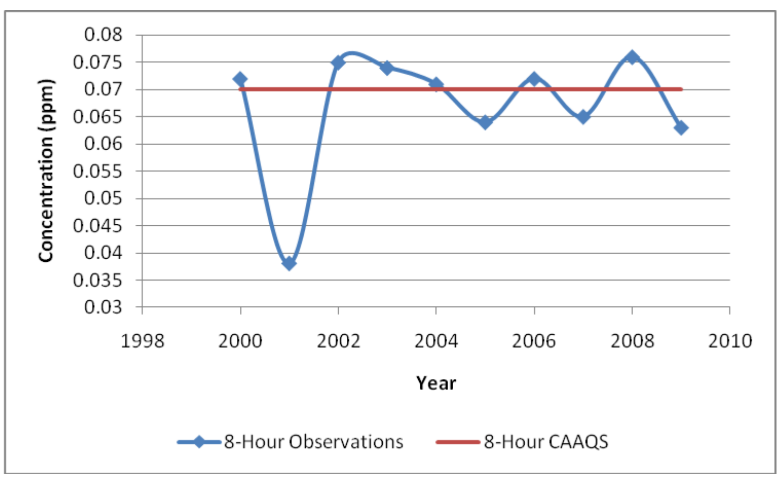
Criteria Air Pollutant	Annual Monitoring Data[1]		
	2007	2008	2009
Ozone (O_3) 1-Hour			
1st High (ppm)	0.072	0.086	0.076
2nd High (ppm)	0.072	0.078	0.071
Days above CAAQS[2]	0	0	0
Ozone (O_3) 8-Hour			
1st High (ppm)[3]	0.065 / 0.064	0.076 / 0.075	0.063 / 0.062
2nd High (ppm)[3]	0.063 / 0.063	0.067 / 0.066	0.060 / 0.060
Days above CAAQS[4]	0	1	0
Days above NAAQS[5]	0	0	0
Inhalable Particulate Matter (PM_{10})			
Highest 24-hour concentration (μg/m^3)[3]	189 / 205	162.4 / 176.8	30.8 / 33.4
Annual arithmetic mean (μg/m^3)[3]	13 / 15	13 / 18	* / *
Calculated number of days above CAAQS[6]	*	*	*
Calculated number of days above NAAQS[7]	7.7	6.1	0.0
Fine Particulate Matter ($PM_{2.5}$)			
Highest 24-hour concentration (μg/m^3)	*	15.1	16.5
Annual arithmetic mean (μg/m^3)	*	*	5.1
Calculated number of days above NAAQS[8]	*	*	0

Source: CARB 2010b.

Notes:

1 Monitoring data from Yreka-Foothill Drive monitoring station.
2 Days above standard = days above 1-hour CAAQS of 0.09 ppm.
3 Different methods of analyzing monitored data are used by CARB and USEPA; therefore, both data are provided, respectively, separated by "/."
4 Days above standard = days above 8-hour CAAQS of 0.070 ppm.
5 Days above standard = days above 8-hour NAAQS of 0.075 ppm.
6 Days above standard = days above 24-hour CAAQS of 50 μg/m^3.
7 Days above standard = days above 24-hour NAAQS of 150 μg/m^3.
8 Days above standard = days above 24-hour NAAQS of 35 μg/m^3.

Key:
* = data not available
ppm = parts per million
μg/m^3 = micrograms per cubic meter
CAAQS = California Ambient Air Quality Standard
NAAQS = National Ambient Air Quality Standard



Source: CARB 2010b.

Figure M-1. 10-Year Trend in Ozone (O_3) Concentrations at Yreka Monitoring Station (Representative of Siskiyou County, California)

Table M-4 summarizes air quality data from monitoring stations in the area of analysis in Oregon. Data from the Klamath Falls monitoring station was used to characterize the ambient air quality near J.C. Boyle Dam. As Table M-4 shows, $PM_{2.5}$ concentrations exceeded the NAAQS during the past three years. The Klamath Falls monitoring station only monitors for PM_{10} and $PM_{2.5}$; therefore, this table does not show other pollutants.

Table M-4. Summary of Pollutant Monitoring Data in Klamath County

Criteria Air Pollutant	Annual Monitoring Data[1]		
	2008	2009	2010
Inhalable Particulate Matter (PM_{10})			
Highest 24-hour concentration (μg/m^3)	77	87	50
Annual arithmetic mean (μg/m^3)	20.7	20.6	15.7
Calculated number of days above NAAQS[2]	0	0	0
Fine Particulate Matter ($PM_{2.5}$)			
98th Percentile 24-hour concentration (μg/m^3)[3]	***52***	***44***	35
Annual arithmetic mean (μg/m^3)[4]	12.5	11.3	9.8

Source: Oregon Department of Environmental Quality 2011.

Notes:

[1] Monitoring data from Klamath Falls monitoring station.

[2] Days above standard = days above 24-hour NAAQS of 150 μg/m^3.

[3] Values shown in ***bold and italics*** are over the NAAQS.

[4] Data excludes documented wildfire days.

Key:

ppm = parts per million

μg/m^3 = micrograms per cubic meter

NAAQS = National Ambient Air Quality Standard

M.2 Assessment Methods

This section describes the methodology used to develop the emission inventories and the comparison of the analysis results for the California site activities to the California Environmental Quality Act significance thresholds.

M.2.1 Emission Calculation Methodology

In general, the construction emissions were estimated from various emission models and spreadsheet calculations, depending on the source type and data availability. The California Air Resources Board (CARB) Urban Emissions Model (URBEMIS) – Version 9.2.4 was used to estimate fugitive dust emissions from the general movement of the construction equipment on unpaved surfaces and excavation activities (cut/fill). Although URBEMIS is capable of estimating emissions from trucks and construction worker commuting vehicles, it is difficult to modify the model's default settings. Additionally, the model was developed specifically for activities completed in California and the exhaust emission components are not suitable for the construction activities that occur in Oregon. URBEMIS was therefore only used to estimate emissions from fugitive dust, which would be applicable in both states, and other methods were used to estimate emissions from non-dust sources.

Although URBEMIS is suitable for estimating fugitive dust emissions from the operation of the construction equipment and excavation activities, it is not suitable for estimating emissions from unpaved haul roads. Emissions from travel on unpaved roads were estimated using the methodology identified in the *Compilation of Air Pollutant Emission Factors (AP-42)* maintained by the United States Environmental Protection Agency (USEPA). Chapter 13.2.2 (USEPA 2006) was used to estimate the appropriate emission rate for unpaved roads.

Exhaust emissions from the off-road construction equipment operating at each dam site were estimated using the OFFROAD2007 and NONROAD2008a emission factor models for California and Oregon, respectively. Since California is unique amongst other states because it can set its own vehicular emission standards as prescribed in Section 209 of the federal Clean Air Act, it developed its own emissions factor model to estimate emissions from off-road equipment. It was assumed in these calculations that all off-road equipment would be diesel-fueled unless specifically identified as non-diesel fueled (e.g., gasoline) by the project consultants.

In a similar vein, exhaust emissions from on-road vehicles, specifically trucks and construction worker vehicles, were estimated using the EMFAC and MOBILE6.2 emission factor models for California and Oregon, respectively. It was assumed that construction workers would only be operating light-duty passenger cars and trucks; therefore, the emission factor calculations were restricted to only these vehicle classes. A combination of gasoline-fueled (catalyst and non-catalyst) and diesel-fueled engines was also used in the calculations. The default fleet mixes for Siskiyou County, California and Klamath County, Oregon were also used based on information contained in EMFAC for California and provided by the Oregon Department of Environmental Quality for Oregon.

Daily and annual emissions for each year of construction were estimated from appropriate emission factors, number of facilities and features being worked, and the associated schedules that were provided by the project consultants. The following sections provide additional discussion of emission estimation methodologies used for each source group.

M.2.1.1 On-Site Building Demolition and Excavation Activities

The URBEMIS model was developed to estimate construction emissions from land development projects. It treats construction in three phases: Phase 1 – demolition, Phase 2 – site grading, and Phase 3 – building construction. For this Proposed Action, URBEMIS was used for fugitive particulate matter, or dust, emissions from demolition and grading (earth cut/fill) activities. The earth cut/fill activity is included in URBEMIS Phase 2 –Site Grading, which allows the user to select one of four tiers of detail to calculate fugitive dust emissions.

Fugitive (re-entrained) dust emissions would occur from the movement of construction equipment at each of the construction sites. As a result, the default emission factor in URBEMIS for average construction activities (10 pounds per acre per day of PM_{10}) was used to estimate fugitive dust emissions from the equipment at the site. It was assumed in the calculations that fugitive dust emissions could occur from the construction equipment during the entire construction schedule. Table M-5 summarizes the size of the construction footprint used in URBEMIS to estimate fugitive dust emissions from the equipment.

Table M-5. Estimated Construction Area (Acres)

Alternative	Iron Gate	Copco 1	Copco 2	J.C. Boyle
Full Facilities Removal	13.1	2.3	2.8	9.7
Partial Facilities Removal	11.7	1.0	0.6	5.1
Fish Passage at Four Dams	5.1	1.5	1.0	2.1
Fish Passage at Two Dams, Remove Copco 1 and Iron Gate	13.1	2.3	1.0	2.1

Source: Wright 2010.

In addition to the re-entrained dust emissions from the movement of equipment at the construction site, emissions could also occur from excavation activities. The next tier in URBEMIS ("Low Level") was used to refine the emissions estimates for any phase or location that involved soil excavation. The construction window for excavation activities was limited to a shorter window than the entire construction schedule during which excavation activities could occur. Table M-6 summarizes the volumes of the excavated earth, which is based on the estimated volume of excavated material (spoils/cut material) increased by a factor of 20 percent to account for the bulk volume. This adjustment was made to account for the fact that the excavated material would take up more volume when removed from the ground than when compacted.

Table M-6. Estimated Bulk Waste Volume for Earth Materials (cubic yards)

Alternative	Iron Gate[1]	Copco 1	Copco 2[1]	J.C. Boyle[1]
Full Facilities Removal	1,300,000	n/a	1,800	170,000
Partial Facilities Removal	1,300,000	n/a	1,800	170,000
Fish Passage at Four Dams	n/a	n/a	n/a	n/a
Fish Passage at Two Dams, Remove Copco 1 and Iron Gate	1,300,000	n/a	n/a	n/a

Source: U.S. Department of the Interior (DOI) 2011.

Notes:

[1] Volumes increased 20 percent for loose earth materials.

In addition to fugitive dust emissions from the construction equipment and cut/fill activities, emissions would also occur from the demolition of existing structures at each of the sites. The quantity of building waste expected to be removed during demolition activities is summarized below.

- Copco No. 1 Dam: 300 cubic yards
- Copco No. 2 Dam: 600 cubic yards

- Iron Gate Dam: 400 cubic yards
- J.C. Boyle Dam: 2,000 cubic yards

Building demolition was only assumed to occur in the alternatives that would involve dam removal (i.e., all but the Fish Passage at Four Dams Alternative). The building removal at Copco 1, however, is required to allow the mobilization of large equipment at the site. As a result, its building demolition is assumed to occur under all alternatives.

M.2.1.2 On-Site (Off-Road) Equipment Engine Exhaust Emissions

Emissions would also occur from the combustion of fuel during operation of the off-road construction equipment at each of the dams. As was previously stated, separate emission factor models (i.e., OFFROAD and NONROAD) are used to estimate emissions in California and Oregon.

Preliminary estimates of the type, size (horsepower), and quantity of construction proposed to be used at each of the dam locations was provided by the project consultants. Engine load factors are also incorporated into the emission factor models. Emission factors for each piece of equipment were then selected based on the equipment type (e.g., cranes, excavators, loaders, etc.) and the engine size. It was conservatively assumed that all equipment located at a dam site could operate simultaneously for the entire shift. Iron Gate would have a maximum operating schedule of 14 hours per day, Copco 1 would operate 16 hours per day, and Copco 2 and J.C. Boyle would operate eight hours per day. The total hours of operation for each piece of equipment was also provided with the equipment list provided by the project consultants. Annual emissions were then calculated from the total hours of operation.

In addition to the mobile construction equipment, several stationary generators would be present at each of the dam locations to provide power for electric-operated equipment. Emission factors from Chapter 3.3 (USEPA 1996a) of AP-42 were used to estimate emissions from these generators.

Furthermore, speciation profiles were needed in many cases to convert emissions of PM_{10} to $PM_{2.5}$. CARB maintains particulate matter size fractions for various types of equipment (CARB 2010a). Profile number 425 (Diesel Vehicle Exhaust) was used to determine the ratio of $PM_{2.5}$ to PM_{10} for equipment located in California. The USEPA also maintains generalized particle size distributions in Appendix B.2 to AP-42 (1996b); these size fractions were used to estimate $PM_{2.5}$ emissions from diesel equipment located in Oregon. Finally, the NONROAD model provides emission estimates in terms of total hydrocarbon emissions. The conversion of total hydrocarbons to VOC was estimated from information contained in the USEPA’s *Conversion Factors for Hydrocarbon Emission Components* (2003) document.

M.2.1.3 Off-Site (On-Road) Haul Truck Engine Exhaust Emissions and Paved Road Dust

The haul truck engine exhaust emissions were calculated based on EMFAC and MOBILE6.2 emission factors for heavy-duty diesel trucks in Siskiyou County, California and Klamath County, Oregon, respectively. Information on the peak daily and project total round trips was provided by the project consultants. The total project trips were assumed to occur evenly throughout the project schedule. The total vehicle miles traveled was determined from the number of trips and estimated distance to haul each component (e.g., earth, concrete, metal, etc.) to disposal sites near the four facilities and to disposal/recycling facilities in Klamath Falls, Medford and Yreka depending on the component.

Emission factors vary by year based on changes in the vehicle fleet mix by older engines retiring from service and improved emission control technologies and standards in newer engines joining the fleet. As a result, two different emission factors are provided by location (state) and pollutant to reflect these changes in the fleet mix.

Re-entrained road dust from haul truck travel was estimated for paved roads. Paved road dust was estimated using emission factors developed by the Midwest Research Institute (MRI 1996). Table M-7 presents the paved road dust emission factors. The emission factor for average road conditions and average daily trips (ADT) was used throughout the emission calculations.

Table M-7. Paved Road Re-entrained Dust Emission Factors

Road Condition	Average Daily Trips (ADT)[1]		
	High	Low	Average[2]
Average conditions[3]	0.37	1.3	0.81
Worst-case conditions[4]	0.64	3.9	2.1

Source: Midwest Research Institute (MRI) 1996.

Notes:

1 "Arterials" and "major streets" were classified by MRI as high-ADT roads, while "collectors" or "local streets" were classified as low-ADT roads.

2 Based on 65 percent of high- and 35 percent of low-ADT silt loading values.

3 Based on median value of MRI sampling data and average vehicle weight of 2.4 tons.

4 Based on 90th percentile of MRI sampling data and average vehicle weight of 2.4 tons.

Key:

PM_{10} = inhalable particulate matter

Additionally, since the MRI emission factors are specific to PM_{10}, CARB size fraction profile number 471 (Paved Road Dust, 97 and after) was used to estimate emissions of $PM_{2.5}$.

M.2.1.4 Construction Worker Commuting

Emissions associated with construction workers commuting to and from the various dam locations were also estimated for each alternative. It was assumed that construction worker vehicles would consist of a mix of passenger cars and light-duty trucks. The combination of diesel and gasoline (catalyst and non-catalyst) vehicles from the various emission factor models was retained in the emission factor estimates. As explained in Section P.2.1.2 for trucks, the EMFAC and MOBILE6.2[1] emission factor models were used to estimate emissions. Re-entrained road dust was estimated using the emission factors provided in Table M-7 for average road conditions and average ADT.

M.2.1.5 Unpaved Road Dust

Fugitive dust emissions would also occur from unpaved roads that are used to haul waste materials. The methodology documented in Section 13.2.2 (USEPA 2006) of AP-42 was used to estimate fugitive dust emissions from the trucks operating on these roads.

The unpaved roads section of AP-42 requires an emission factor to be calculated using variables like the surface material silt content and mean vehicle weight on the roads. Two different equations are provided in AP-42 depending on whether the road is located at an industrial site or a publicly accessible road. The latter equation for publicly accessible roads assumes that the road will be dominated by light-duty vehicles; since trucks will be the primary equipment on the various haul roads, the equation for industrial sites (shown below) was used to estimate emissions.

$$E = k(s/12)^a (W/3)^b$$

Where:

E = size-specific emission factor, pounds per vehicle mile traveled (lb/vehicle miles traveled [VMT])

k, a, and b = empirical constants (see Table P-8)

s = surface material silt content, %

W = mean vehicle weight, tons

A silt content of 0.1 percent was used for all haul roads, which is the lowest silt content estimated for gravel roads by the USEPA (1998). The vehicular weight was estimated at 36.5 tons for empty trucks and 80 tons for loaded trucks (Caterpillar 2010). Table M-8 summarizes the empirical constants used in the preceding equation and the calculated emission factors for empty and loaded trucks.

[1] In 2010, the USEPA approved the use of the Motor Vehicle Emissions Simulator (MOVES) model for official State implementation air quality plan submissions to the USEPA and for transportation conformity analyses outside of California (75 FR 9411). The approval also started a two-year grace period that ends on March 2, 2012; the use of MOVES is not required during this timeframe. Since this analysis was completed during the grace period and project-level data was not available for MOVES, MOBILE6.2 was used for the analysis.

Table M-8. Empirical Constants and Emission Factors for Unpaved Roads

Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.15	1.5
a	0.9	0.9
b	0.45	0.45
E, Empty (lb/VMT)	0.0062	0.062
E, Loaded (lb/VMT)	0.0088	0.088

Source: USEPA 2006.
Key:
lb/VMT = pounds per vehicle mile traveled
$PM_{2.5}$ = fine particulate matter
PM_{10} = inhalable particulate matter

The emission factors provided in Table M-8 are for uncontrolled fugitive dust emissions. Natural mitigation occurs from annual precipitation, the control efficiency of which can be estimated from the following equation.

$$E_{ext} = E[(365 - P)/365]$$

Where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = unpaved road dust emission factor (see Table M-8)

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

The number of days of precipitation was estimated at approximately 88 days for Klamath County and 84 days for Siskiyou County. The control efficiency of natural mitigation was therefore estimated as 76 percent and 77 percent, respectively, for Klamath and Siskiyou Counties.

M.3 Emission Inventories

Emission inventories were completed for each of the dam locations and alternatives as described in the previous sections. As is shown in Table M-9, peak daily emissions of NOx would be significant under each of the proposed alternatives except Alternative 4; and PM_{10} peak daily emissions would be significant under each of the alternatives except Alternative 4. As a result, emissions of NOx and PM_{10} would need to be mitigated. Annual emissions for the total project are provided in Table M-10 for informational purposes.

Table M-9. Summary of Peak Daily Emissions by Alternative

Alternative	Peak Daily Emissions (pounds per day)[1]					
	VOC	**CO**	**NOx**	**SOx**	**PM_{10}**	**$PM_{2.5}$**
Alt. 2: Full Facilities Removal	131	584	**650**	9	**503**	248
Alt. 3: Partial Facilities Removal	128	570	**625**	9	**484**	244
Alt 4: Fish Passage at Four Dams	11	63	59	4	11	6
Alt 5: Fish Passage at Two Dams	117	552	**620**	7	**399**	225
Threshold of Significance	250	2,500	250	250	250	250

Notes:

[1] Values shown in **bold** exceed the California Environmental Quality Act thresholds of significance.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Table M-10. Summary of Annual Emissions by Alternative

Alternative	Annual Emissions (tons per year)[1]					
	VOC	**CO**	**NOx**	**SOx**	**PM_{10}**	**$PM_{2.5}$**
2020						
Alt. 2: Full Facilities Removal	6	24	28	1	20	11
Alt. 3: Partial Facilities Removal	6	23	26	<1	20	11
Alt. 4: Fish Passage at Four Dams[2]	2	10	5	<1	2	1
Alt. 5: Fish Passage at Two Dams	4	20	22	<1	18	10

Notes:

[1] Emissions shown are the total emissions for all four dams.

[2] Emissions for Alternative 4 represent the worst-case year for emissions because dam demolition activities occur during different years for each dam site.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.3.1 Alternative 2: Full Facilities Removal (Proposed Action)

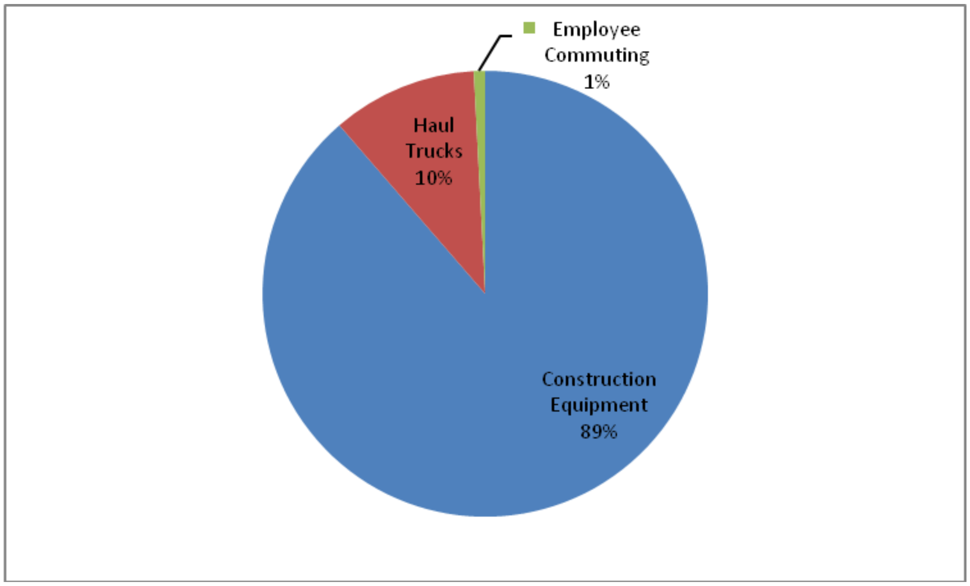
A summary of peak daily emissions associated with the Proposed Action is provided in Table M-11. Emissions are identified for each of the major components of construction, including off-road construction equipment, on-road trucks, construction worker commuting vehicles, and fugitive dust from vehicle re-entrainment on unpaved roads and excavation/grading activities. Peak daily emissions of NOx and PM_{10}would be significant under this alternative.

Table M-11. Summary of Peak Daily Emissions for Proposed Action

Source	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Iron Gate						
Construction Equipment	63	248	**313**	2	12	11
Haul Trucks	3	12	34	<1	5	2
Employee Commuting Vehicles	1	11	1	<1	4	1
Unpaved Roads	--	--	--	--	31	3
Excavation/Grading	--	--	--	--	157	33
Iron Gate Subtotal	67	**272**	**348**	2	210	50
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	4	11	<1	2	1
Employee Commuting Vehicles	1	13	1	<1	3	1
Unpaved Roads	--	--	--	--	2	<1
Excavation/Grading	--	--	--	--	161	159
Copco 1 Subtotal	27	176	129	1	174	165
Copco 2						
Construction Equipment	19	56	80	1	4	3
Haul Trucks	3	12	32	<1	5	2
Employee Commuting Vehicles	1	16	2	<1	2	<1
Unpaved Roads	--	--	--	--	4	<1
Excavation/Grading	--	--	--	--	3	1
Copco 2 Subtotal	19	56	80	1	4	3
J.C. Boyle						
Construction Equipment	13	22	54	5	9	8
Haul Trucks	1	1	4	<1	2	<1
Employee Commuting Vehicles	2	31	1	<1	2	<1
Unpaved Roads	--	--	--	--	5	1
Excavation/Grading	--	--	--	--	84	17
J.C. Boyle Subtotal	15	54	60	5	103	27
Total Emissions	131	**584**	**650**	9	**503**	248
California Emissions	116	**531**	**590**	4	**401**	221
Oregon Emissions	15	54	60	5	103	27
Significance Criteria	250	2,500	250	250	250	250

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

As shown in Table M-11, NOx and PM_{10} are over the significance criteria. The majority of emissions from PM_{10} are already controlled to a high degree by various fugitive dust control measures; therefore, it will be difficult to reduce emissions to a greater degree. As a result, mitigation measures should focus on reducing NOx emissions. Figure M-2 summarizes the peak NOx daily emissions from all four dams. As is shown in the figure, the most focus should be placed on reducing emissions from off-road construction equipment.



Source: CDM 2011.

Figure M-2. Distribution of Peak Daily NOx Emissions at All Dams for Full Facilities Removal (Proposed Action)

Table M-12 summarizes annual emissions for each of the sites.

Table M-12. Summary of Annual Emissions for Full Facilities Removal (Proposed Action)

Alternative	Annual Emissions (tons per year)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
2020						
Iron Gate	3	11	14	<1	10	2
Copco 1	1	7	5	<1	8	7
Copco 2	1	3	5	<1	<1	<1
J.C. Boyle	1	3	5	<1	3	1
Project Total (2020)	6	24	28	1	20	11
California Total	5	21	23	<1	18	10
Oregon Total	1	3	5	<1	3	1

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.3.2 Alternative 3: Partial Facilities Removal Alternative

A summary of peak daily emissions associated with the Partial Facilities Removal Alternative is provided in Table M-13. Peak daily emissions of NOx and PM_{10} would remain significant under this alternative.

Table M-13. Summary of Peak Daily Emissions for Partial Facilities Removal Alternative

Source	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Iron Gate						
Construction Equipment	63	248	**313**	2	12	11
Haul Trucks	2	11	30	<1	5	1
Employee Commuting	1	11	1	<1	4	1
Unpaved Roads	--	--	--	--	31	3
Excavation/Grading	--	--	--	--	156	33
Iron Gate Subtotal	66	**270**	**344**	2	208	49
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	2	6	<1	1	<1
Employee Commuting	1	11	1	<1	3	1
Unpaved Roads	--	--	--	--	2	<1
Excavation/Grading	--	--	--	--	159	158
Copco 1 Subtotal	27	173	124	1	171	165
Copco 2						
Construction Equipment	19	56	80	1	4	3
Haul Trucks	2	8	22	<1	3	1
Employee Commuting	1	16	2	<1	2	<1
Unpaved Roads	--	--	--	--	2	<1
Excavation/Grading	--	--	--	--	1	<1
Copco 2 Subtotal	21	80	103	1	12	5
J.C. Boyle						
Construction Equipment	12	19	49	5	8	7
Haul Trucks	<1	1	3	<1	1	<1
Employee Commuting	1	28	1	<1	2	<1
Unpaved Roads	--	--	--	--	5	1
Excavation/Grading	--	--	--	--	77	16
J.C. Boyle Subtotal	14	48	53	5	94	25
Total Emissions	128	570	**625**	9	**484**	244
California Emissions	115	522	**571**	4	**390**	219
Oregon Emissions	14	48	53	5	94	25
Significance Criteria	250	2,500	250	250	250	250

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Compared to the Proposed Action, this alternative generally results in fewer PM_{10} and $PM_{2.5}$ emissions associated with excavation and cut/fill activities because the footprint on which equipment would be operating is smaller than the Proposed Action. Emissions associated with the other components are relatively unaffected because the peak number of truck trips, construction equipment, or employees does not change between the two alternatives. An exception occurs at J.C. Boyle, which requires fewer workers and less construction equipment under Alternative 3 compared to the Proposed Action.

Table M-14 summarizes annual emissions for each of the sites. As shown in the table, emissions for each year of construction are estimated to be generally lower compared to those under the Proposed Action. This is related to the reduced level of construction activities that would occur under this alternative compared to those under the Proposed Action.

Table M-14. Summary of Annual Emissions for Partial Facilities Removal Alternative

Alternative	Annual Emissions (tons per year)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
2020						
Iron Gate	3	11	14	<1	10	2
Copco 1	1	7	5	<1	7	7
Copco 2	1	3	4	<1	<1	<1
J.C. Boyle	1	2	3	<1	2	1
Project Total (2020)	6	23	26	<1	20	11
California Total	5	21	23	<1	17	10
Oregon Total	1	2	3	<1	2	1

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.3.3 Alternative 4: Fish Passage at Four Dams

A summary of peak daily emissions associated with the Fish Passage at Four Dams Alternative is provided in Table M-15. Peak daily emissions of each pollutant would be substantially lower than emissions under the Proposed Action. This is largely based on the fact that the dams will remain in place and fugitive dust emissions will be minimal. The reduced level of construction activities compared to that under the Proposed Action also results in fewer emissions from the components (i.e., construction equipment, trucks, and construction worker commuting vehicles). Peak daily emissions would be less than significant for all pollutants.

Table M-15. Summary of Peak Daily Emissions for Fish Passage at Four Dams Alternative

Source	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Iron Gate (2023)						
Construction Equipment	10	54	52	<1	2	2
Haul Trucks	1	3	7	<1	1	<1
Employee Commuting	1	6	1	<1	2	<1
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	2	<1
Iron Gate Subtotal	11	63	59	<1	8	3
Copco 1 (2025)						
Construction Equipment	9	51	37	<1	2	1
Haul Trucks	1	3	7	<1	2	<1
Employee Commuting	1	4	<1	<1	1	<1
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	1	<1
Copco 1 Subtotal	9	51	37	<1	2	1
Copco 2 (2024)						
Construction Equipment	9	51	42	<1	2	2
Haul Trucks	1	3	8	<1	2	<1
Employee Commuting	<1	3	<1	<1	1	<1
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	<1	<1
Copco 2 Subtotal	10	58	50	<1	5	2
J.C. Boyle (2022)						
Construction Equipment	8	14	45	3	6	5
Haul Trucks	1	1	5	<1	3	1
Employee Commuting	<1	<1	<1	<1	1	<1
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	1	<1
J.C. Boyle Subtotal	9	16	50	4	11	6
Maximum Daily Emissions	11	63	59	4	11	6
Significance Criteria[1]	250	2,500	250	250	250	250

Note:

[1] Demolition activities at each dam site occur during different years and do not overlap; therefore, the maximum daily emissions used for significance determinations.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Table M-16 summarizes annual emissions for each of the sites. As shown in the table, emissions for each year of construction are estimated to be generally lower compared to those under the Proposed Action. This is related to the reduced level of construction activities that would occur under this alternative compared to those under the Proposed Action.

Table M-16. Summary of Fish Passage at Four Dams Alternative

Alternative	Annual Emissions (tons per year)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Iron Gate (2023)	2	10	5	<1	2	1
Copco 1 (2025)	1	7	3	<1	2	<1
Copco 2 (2024)	1	4	1	<1	1	<1
J.C. Boyle (2022)	<1	<1	2	<1	1	<1
Maximum Annual Emissions	2	10	5	<1	2	1

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.3.4 Alternative 5: Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

A summary of peak daily emissions associated with the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative is provided in Table M-17. Peak daily emissions of each pollutant are substantially less than emissions under the Proposed Action. This is largely based on the fact that two dams will remain in place and fugitive dust emissions will be minimal. The reduced level of construction activities compared to that under the Proposed Action also results in fewer emissions from the components (i.e., construction equipment, trucks, and construction worker commuting vehicles). Peak daily emissions of NOx and PM_{10} would be significant under this alternative.

Table M-17. Summary of Peak Daily Emissions for Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative

Source	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Iron Gate						
Construction Equipment	63	248	**313**	2	12	11
Haul Trucks	2	11	30	0	5	1
Employee Commuting	1	22	2	0	5	1
Unpaved Roads	--	--	--	--	31	3
Excavation/Grading	--	--	--	--	157	33
Iron Gate Subtotal	67	**282**	**345**	2	209	49
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	4	11	0	2	1
Employee Commuting	1	16	2	0	3	1
Unpaved Roads	--	--	--	--	2	0
Excavation/Grading	--	--	--	--	160	159
Copco 1 Subtotal	28	179	129	1	173	165
Copco 2						
Construction Equipment	11	52	70	0	3	3
Haul Trucks	1	4	12	0	2	1
Employee Commuting	0	4	0	0	1	0
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	0	0
Copco 2 Subtotal	12	61	82	0	6	4
J.C. Boyle						
Construction Equipment	8	18	56	4	6	6
Haul Trucks	1	2	6	0	3	1
Employee Commuting	1	12	0	0	1	0
Unpaved Roads	--	--	--	--	--	--
Excavation/Grading	--	--	--	--	1	0
J.C. Boyle Subtotal	10	32	63	4	11	7
Total Emissions	117	552	**620**	7	**399**	225
California Emissions	107	521	**557**	3	**388**	218
Oregon Emissions	10	32	63	4	11	7
Significance Criteria	250	2,500	250	250	250	250

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Table M-18 summarizes annual emissions for each of the sites. As shown in the table, emissions for construction are estimated to be generally lower in 2020 as compared to those under the Proposed Action. This is related to the reduced level of construction activities that would occur under this alternative compared to those under the Proposed Action.

Table M-18. Summary of Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Alternative	Annual Emissions (tons per year)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
2020						
Iron Gate	3	12	14	<1	10	2
Copco 1	1	7	5	<1	8	7
Copco 2	<1	1	1	<1	<1	<1
J.C. Boyle	<1	1	2	<1	<1	<1
Project Total (2020)	4	20	22	<1	18	10
California Total	4	19	20	<1	18	10
Oregon Total	<1	1	2	<1	<1	<1

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SOx = sulfur oxides
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

M.4 Mitigation Measures

Several mitigation measures would be required to reduce emissions of PM_{10}, $PM_{2.5}$, and NOx, depending on the alternative. The following mitigation measures would be used as necessary to reduce emissions:

- AQ-1 – Any off-road construction equipment (e.g., loaders, excavators, etc.) must be equipped with engines that meet the model year (MY) 2015 emission standards for off-road compression-ignition (diesel) engines (13 CCR 2420-2425.1). Older model year engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

- AQ-2 – Any on-road construction equipment (e.g., pick-up trucks at the construction sites) must be equipped with engines that meet the MY 2000 or on-road emission standards.

- AQ-3 – Any trucks used to transport materials to or from the construction sites must be equipped with engines that meet the MY 2010 or later emission standards for on-road heavy-duty engines and vehicles (13 CCR 1956.8). Older model engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

- AQ-4 – Dust control measures will be incorporated to the maximum extent feasible during blasting operations at Copco 1 Dam. The following control measures will be used during blasting activities:

    - Conduct blasting on calm days to the extent feasible. Wind direction with respect to nearby residences must be considered.

- Design blast stemming to minimize dust and to control fly rock.
- Install wind fence for control of windblown dust

Mitigated measures were calculated as described in the previous sections. Table M-19 summarizes mitigated measures by alternative.

Table M-19. Summary of Mitigated Emissions by Alternative

Alternative[1]	Peak Daily Emissions (lbs/day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Full Facilities Removal	66	405	146	3	**309**	74
Partial Facilities Removal	64	394	137	3	**294**	60
Fish Passage at Two Dams	54	372	156	3	209	44
Significance Criterion[2]	250	2,500	250	250	250	250

Note:
[1] Alternative 4 (Fish Passage at Four Dams) not included in table because mitigation was not required.

As shown in Table M-19, emissions of PM_{10} would remain significant for the Proposed Action and the Partial Facilities Removal Alternative. As a result, PM_{10} emissions would remain significant and unavoidable for these two alternatives.

M.5 References

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Table M1A. Summary of Daily Mitigated Emissions

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Grand Total						
Alternative 2	66	405	146	3	309	74
Alternative 3	64	394	137	3	294	60
Alternative 5	54	372	156	3	209	44
Threshold	250	2,500	250	250	250	250

Note:

Alternative 4 not included because mitigation not required.

Key:

CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M1B. Alternative 2 Daily Mitigated Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	36	225	63	2	3	3
Haul Trucks	1	7	14	0	5	1
Employee Commuting	1	11	1	0	4	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	157	33
TOTAL	38	242	78	2	199	40
Copco 1						
Construction Equipment	18	130	51	1	2	9
Haul Trucks	0	2	4	0	2	0
Employee Commuting	1	13	1	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	161	159
TOTAL	19	144	57	1	170	169
Copco 2						
Construction Equipment	13	51	29	1	1	6
Haul Trucks	1	6	13	0	4	1
Employee Commuting	1	16	2	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	4	0
Fugitive Dust - Materials	--	--	--	--	3	1
TOTAL	15	72	44	1	14	8
JC Boyle						
Construction Equipment	11	58	19	1	1	7
Haul Trucks	1	1	4	0	2	0
Employee Commuting	2	31	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	5	1
Fugitive Dust - Materials	--	--	--	--	84	17
TOTAL	13	90	25	1	95	26
Grand Total	85	549	204	5	478	243
California Total	72	459	179	4	384	218
Oregon Total	13	90	25	1	95	26

Peak Daily	66	405	146	3	309	74
California Total	53	315	122	3	214	48
Oregon Total	13	90	25	1	95	26

Note:
Peak daily emissions do not include Copco 1.
Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M1C. Alternative 3 Daily Mitigated Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	36	225	63	2	3	3
Haul Trucks	1	6	12	0	4	1
Employee Commuting	1	11	1	0	4	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	156	33
TOTAL	38	241	76	2	198	40
Copco 1						
Construction Equipment	18	130	51	1	2	2
Haul Trucks	0	1	3	0	1	0
Employee Commuting	1	11	1	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	159	158
TOTAL	19	142	55	1	167	161
Copco 2						
Construction Equipment	13	51	29	1	1	1
Haul Trucks	1	4	9	0	3	1
Employee Commuting	1	16	2	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	14	70	40	1	9	3
J.C. Boyle						
Construction Equipment	10	53	18	1	1	1
Haul Trucks	0	1	3	0	1	0
Employee Commuting	1	28	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	5	1
Fugitive Dust - Materials	--	--	--	--	77	16
TOTAL	12	82	22	1	87	18
Grand Total	83	536	193	4	461	222
California Total	71	454	171	4	374	204
Oregon Total	12	82	22	1	87	18

Peak Daily	64	394	137	3	294	60
California Total	52	311	116	3	207	42
Oregon Total	12	82	22	1	87	18

Note:
Peak daily emissions do not include Copco 1.
Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M1D. Alternative 5 Daily Mitigated Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	36	225	63	2	3	3
Haul Trucks	2	11	30	0	5	1
Employee Commuting	1	22	2	0	5	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	157	33
TOTAL	40	258	95	2	200	41
Copco 1						
Construction Equipment	18	130	51	1	2	2
Haul Trucks	1	4	11	0	2	1
Employee Commuting	1	16	2	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	160	159
TOTAL	19	149	64	1	169	162
Copco 2						
Construction Equipment	6	48	26	0	1	1
Haul Trucks	1	4	12	0	2	1
Employee Commuting	0	4	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	7	57	38	0	4	2
J.C. Boyle						
Construction Equipment	6	45	16	0	1	1
Haul Trucks	1	2	6	0	3	1
Employee Commuting	1	12	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	7	58	23	0	6	2
Grand Total	73	522	220	4	378	206
California Total	66	464	197	3	373	204
Oregon Total	7	58	23	0	6	2

Peak Daily	54	372	156	3	209	44
California Total	47	314	133	2	204	42
Oregon Total	7	58	23	0	6	2

Note:
Peak daily emissions do not include Copco 1.
Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M1E. Summary of Annual Mitigated Emissions

	2020 Annual Emissions (tpy)					
	ROG	CO	NOx	SOx	PM10	PM2.5
Alternative 2	4	24	9	0	19	11
Alternative 3	4	22	8	0	19	10
Alternative 5	3	19	7	0	17	9

Note:
Alternative 4 not included because mitigation not required
Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M1F. Alternative 2 Annual Mitigated Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	2	9	3	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	2	10	3	0	9	2
Copco 1						
Construction Equipment	1	5	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	6	2	0	7	7
Copco 2						
Construction Equipment	1	3	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	3	2	0	0	0
JC Boyle						
Construction Equipment	1	4	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	2	0
TOTAL	1	5	2	0	2	1
Project Total	4	24	9	0	19	11
California Total	3	19	7	0	17	10
Oregon Total	1	5	2	0	2	1

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M1G. Alternative 3 Annual Mitigated Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	2	9	3	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	2	10	3	0	9	2
Copco 1						
Construction Equipment	1	5	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	6	2	0	7	7
Copco 2						
Construction Equipment	1	2	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	3	2	0	0	0
J.C. Boyle						
Construction Equipment	1	3	1	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	2	0
TOTAL	1	4	1	0	2	0
Project Total	4	22	8	0	19	10

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M1H. Alternative 5 Annual Mitigated Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	2	9	3	0	0	0
Haul Trucks	0	0	1	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	2	11	4	0	9	2
Copco 1						
Construction Equipment	1	5	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	6	2	0	7	7
Copco 2						
Construction Equipment	0	1	0	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	0	1	1	0	0	0
J.C. Boyle						
Construction Equipment	0	1	1	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	0	2	1	0	0	0
Project Total	3	19	7	0	17	9

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M2A. Summary of Daily Mitigated Off-Road Construction Emissions (Alternative 2)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	36	225	63	2	3	3
Copco 1	18	130	51	1	2	9
Copco 2	13	51	29	1	1	6
J.C. Boyle	11	58	19	1	1	7
Total	77	463	163	4	7	25
California %	86%	87%	88%	87%	88%	72%
Oregon %	14%	13%	12%	13%	12%	28%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M2B. Summary of Annual Mitigated Off-Road Construction Emissions (Alternative 2)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	1.5	9.3	2.6	0.1	0.1	0.1
Copco 1	0.7	5.1	2.0	0.0	0.1	0.4
Copco 2	0.8	2.5	1.8	0.1	0.1	0.3
J.C. Boyle	0.9	4.3	1.7	0.1	0.1	0.5
Total	3.9	21.3	8.2	0.2	0.4	1.2
California %	77%	80%	79%	75%	79%	63%
Oregon %	23%	20%	21%	25%	21%	37%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M2C. Mitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 2)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.04	0.39	3.03	0.82	0.02	0.03	0.39	0.02	0.13	0.03	0.00	0.00	0.02
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.00	0.19	4.46	0.40	0.01	0.02	0.01	0.01	0.19	0.02	0.00	0.00	0.00
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX1200	Excavators	646	Diesel	0.06	0.43	0.12	0.00	0.00	0.00	5.02	34.60	9.30	0.19	0.35	0.32	0.21	1.44	0.39	0.01	0.01	0.01
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.08	0.46	0.12	0.00	0.00	0.00	20.31	124.77	33.29	0.65	1.30	1.19	0.84	5.18	1.38	0.03	0.05	0.05
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.07	0.45	0.12	0.00	0.00	0.00	1.48	9.59	2.57	0.05	0.10	0.09	0.06	0.40	0.11	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.19	2.11	0.23	0.01	0.06	0.04	0.01	0.09	0.01	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.06	0.62	1.74	0.00	0.06	0.04	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.08	0.76	2.12	0.00	0.08	0.05	0.00	0.03	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.01	0.56	10.47	0.91	0.02	0.04	0.04	0.02	0.43	0.04	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.05	1.44	0.13	0.00	0.00	0.00	1.10	31.08	2.84	0.07	0.10	0.10	0.05	1.29	0.12	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	36.18	224.75	63.11	1.57	2.75	2.89
Total Annual 2020 (tpy)	1.5	9.3	2.6	0.1	0.1	0.1

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
[blue shading] Onroad vehicle - emissions estimated by EMFAC2007
[green shading] Stationary source - emissions estimated by AP-42 for diesel engines

Table M2D. Mitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 2)

Maximum Daily Work Hours 8

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Quantity					2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.04	0.44	3.46	0.94	0.02	0.03	0.44	0.02	0.13	0.04	0.00	0.00	0.02
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.05	0.22	5.10	0.46	0.01	0.02	0.22	0.01	0.20	0.02	0.00	0.00	0.01
1	0	Excavator - hydraulic ram	321	Diesel	0.06	0.39	0.10	0.00	0.00	0.06	0.32	2.19	0.59	0.01	0.02	0.32	0.01	0.09	0.02	0.00	0.00	0.01
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	0.08	0.54	0.14	0.00	0.01	0.08	0.59	4.21	1.09	0.03	0.04	0.59	0.02	0.16	0.04	0.00	0.00	0.02
3	0	Excavator - <20,000 lb	168	Diesel	0.08	1.62	0.14	0.00	0.01	0.08	0.68	14.36	1.27	0.03	0.05	0.68	0.03	0.56	0.05	0.00	0.00	0.03
1	0	Loader - WA250 IT	138	Diesel	0.06	1.47	0.13	0.00	0.01	0.06	0.15	3.58	0.32	0.01	0.01	0.15	0.01	0.14	0.01	0.00	0.00	0.01
1	0	Loader - WA450	273	Diesel	0.05	0.38	0.10	0.00	0.00	0.05	0.23	1.82	0.49	0.01	0.02	0.23	0.01	0.07	0.02	0.00	0.00	0.01
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	0.08	0.46	0.12	0.00	0.00	0.08	0.87	5.33	1.42	0.03	0.06	0.87	0.03	0.21	0.06	0.00	0.00	0.03
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.66	7.32	0.79	0.02	0.21	0.15	0.03	0.29	0.03	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.22	2.15	6.05	0.01	0.22	0.16	0.01	0.08	0.24	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.27	2.62	7.37	0.02	0.27	0.19	0.01	0.10	0.29	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.99	10.93	1.18	0.03	0.32	0.22	0.04	0.43	0.05	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.10	0.63	11.97	1.04	0.02	0.04	0.63	0.02	0.47	0.04	0.00	0.00	0.02
1	1	Engine generator, 6.5 KW	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	106	Diesel	0.07	1.63	0.68	0.00	0.01	0.07	1.09	24.37	10.22	0.05	0.08	1.09	0.04	0.95	0.40	0.00	0.00	0.04
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	0.06	0.50	0.14	0.00	0.00	0.06	2.35	20.38	5.55	0.11	0.20	2.35	0.09	0.79	0.22	0.00	0.01	0.09
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	0.07	1.63	0.68	0.00	0.01	0.07	0.27	6.09	2.55	0.01	0.02	0.27	0.01	0.24	0.10	0.00	0.00	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	17.76	129.61	51.47	1.05	2.32	9.23
Total Annual 2020 (tpy)	0.69	5.05	2.01	0.04	0.09	0.36

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M2E. Mitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 2)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	12,111	1,096	8	0.04	0.29	0.08	0.00	0.00	0.04	0.22	1.73	0.47	0.01	0.02	0.22	0.02	0.12	0.03	0.00	0.00	0.02
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	0.05	1.11	0.10	0.00	0.00	0.05	0.22	5.10	0.46	0.01	0.02	0.22	0.01	0.30	0.03	0.00	0.00	0.01
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	24,408	1,808	8	0.06	0.39	0.10	0.00	0.00	0.06	0.64	4.39	1.18	0.02	0.04	0.64	0.04	0.25	0.07	0.00	0.00	0.04
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	29,548	2,192	8	0.06	0.39	0.10	0.00	0.00	0.06	0.64	4.39	1.18	0.02	0.04	0.64	0.04	0.30	0.08	0.00	0.00	0.04
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	0.06	0.49	0.13	0.00	0.00	0.06	0.52	4.25	1.12	0.03	0.04	0.52	0.04	0.29	0.08	0.00	0.00	0.04
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	0.05	0.38	0.10	0.00	0.00	0.05	0.39	3.17	0.86	0.02	0.03	0.39	0.00	0.03	0.01	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	11,686	1,408	8	0.08	0.46	0.12	0.00	0.00	0.08	1.11	6.80	1.81	0.04	0.07	1.11	0.05	0.30	0.08	0.00	0.00	0.05
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	0.07	0.56	0.15	0.00	0.01	0.07	0.30	2.33	0.61	0.01	0.02	0.30	0.01	0.07	0.02	0.00	0.00	0.01
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	1.64	15.84	44.50	0.10	1.61	1.14	0.11	1.07	3.01	0.01	0.11	0.08	0.01	0.07	0.21	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	1.64	15.84	44.50	0.10	1.61	1.14	0.07	0.65	1.84	0.00	0.07	0.05	0.00	0.04	0.13	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	0.10	1.94	0.17	0.00	0.01	0.10	0.32	5.98	0.52	0.01	0.02	0.32	0.00	0.01	0.00	0.00	0.00	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	1.14	3.03	14.06	0.93	1.00	0.97	0.78	2.08	9.67	0.64	0.69	0.67	0.05	0.14	0.66	0.04	0.05	0.05
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.50	0.16	0.25	0.01	0.02	0.02
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	2,367	1,096	8	0.07	1.63	0.68	0.00	0.01	0.07	0.08	1.72	0.72	0.00	0.01	0.08	0.01	0.12	0.05	0.00	0.00	0.01
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	6,313	2,192	8	0.07	1.63	0.68	0.00	0.01	0.07	0.21	4.60	1.93	0.01	0.02	0.21	0.01	0.32	0.13	0.00	0.00	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	12.85	50.61	29.08	1.03	1.44	5.66
Total Annual 2020 (tpy)	0.79	2.53	1.82	0.07	0.09	0.29

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M2F. Mitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 2)

Maximum Daily Work Hours 8 hours

Note: Emission calculations assume that construction equipment meet California emission standards for MY2015 and newer equipment

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	Fuel Type	OFFROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Hours	VOC	CO	NOx	SOx	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Cranes	335	23,603	2,136	8	0.04	0.29	0.08	0.00	0.00	0.04	0.22	1.73	0.47	0.01	0.02	0.22	0.03	0.23	0.06	0.00	0.00	0.03
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Cranes	130	3,256	800	8	0.05	1.11	0.10	0.00	0.00	0.05	0.22	5.10	0.46	0.01	0.02	0.22	0.01	0.13	0.01	0.00	0.00	0.01
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Diesel	Excavators	321	57,672	4,272	8	0.06	0.39	0.10	0.00	0.00	0.06	0.64	4.39	1.18	0.02	0.04	0.64	0.08	0.59	0.16	0.00	0.01	0.08
2	Hydraulic excavator, 2.5 cy	Diesel	Excavators	321	57,587	4,272	8	0.06	0.39	0.10	0.00	0.00	0.06	0.64	4.39	1.18	0.02	0.04	0.64	0.08	0.59	0.16	0.00	0.01	0.08
1	Hydraulic excavator, 6 cy	Diesel	Excavators	513	11,014	488	8	0.06	0.43	0.12	0.00	0.00	0.06	0.57	3.92	1.06	0.02	0.04	0.57	0.02	0.12	0.03	0.00	0.00	0.02
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Rubber Tired Loaders	246	11,912	1,504	8	0.06	0.49	0.13	0.00	0.00	0.06	0.52	4.25	1.12	0.03	0.04	0.52	0.02	0.20	0.05	0.00	0.00	0.02
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Off-Highway Trucks	415	16,600	2,000	8	0.08	0.46	0.12	0.00	0.00	0.08	2.77	17.01	4.54	0.09	0.18	2.77	0.07	0.43	0.11	0.00	0.00	0.07
1	Crawler dozer, Cat238	Diesel	Crawler Tractors	238	9,280	1,000	8	0.07	0.56	0.15	0.00	0.01	0.07	0.30	2.33	0.61	0.01	0.02	0.30	0.02	0.15	0.04	0.00	0.00	0.02
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.03	0.02	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Off-Highway Trucks	175	12,582	2,104	8	0.10	1.94	0.17	0.00	0.01	0.10	0.32	5.98	0.52	0.01	0.02	0.32	0.04	0.79	0.07	0.00	0.00	0.04
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.03	0.09	0.43	0.03	0.03	0.03
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	9.79	3.16	4.99	0.27	0.33	0.31	3.63	1.17	1.85	0.10	0.12	0.11	0.43	0.14	0.22	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Other Construction Equipment	60	5,754	2,136	8	0.07	1.63	0.68	0.00	0.01	0.07	0.08	1.72	0.72	0.00	0.01	0.08	0.01	0.23	0.10	0.00	0.00	0.01
2	Air compressor, 250 cfm, 100 psi	Diesel	Other Construction Equipment	80	12,303	4,272	8	0.07	1.63	0.68	0.00	0.01	0.07	0.21	4.60	1.93	0.01	0.02	0.21	0.03	0.61	0.26	0.00	0.00	0.03

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	10.62	57.88	19.20	0.56	0.85	6.82
Total Annual 2020 (tpy)	0.91	4.34	1.73	0.06	0.08	0.46

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per year

Legend:
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M2G. Mitigated Daily Haul Truck Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Road Conditions	Average
ADT	Average

		Peak Daily	Round Trip	Daily Mitigated Emissions (lbs/day) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	160	1	0.09	0.17	0.59	0.00	0.31	0.01	0.01	0.00	0.29	0.06	0.01	0.00	0.00	0.04
(Oregon)	Concrete	50	3	0.09	0.16	0.56	0.00	0.29	0.01	0.01	0.00	0.27	0.05	0.01	0.00	0.00	0.04
	Metal	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	Building Waste	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	J.C. Boyle Subtotal	230	92	0.70	1.23	4.42	0.03	2.30	0.08	0.07	0.03	2.13	0.42	0.07	0.02	0.01	0.32
Copco 1	Concrete	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
(California)	Metal	5	62	0.19	0.91	1.90	0.01	0.65	0.05	0.02	0.02	0.55	0.14	0.05	0.01	0.01	0.08
	Building Waste	5	62	0.19	0.91	1.90	0.01	0.65	0.05	0.02	0.02	0.55	0.14	0.05	0.01	0.01	0.08
	Copco 1 Subtotal	60	126	0.44	2.10	4.41	0.03	1.50	0.12	0.06	0.04	1.29	0.33	0.11	0.01	0.02	0.19
Copco 2	Earth	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
(California)	Concrete (dam)	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
	Concrete (plant)	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (dam)	5	62	0.19	0.91	1.90	0.01	0.65	0.05	0.02	0.02	0.55	0.14	0.05	0.01	0.01	0.08
	Metal (plant)	10	56	0.34	1.64	3.43	0.02	1.17	0.09	0.04	0.03	1.00	0.26	0.08	0.01	0.01	0.15
	Building Waste	10	56	0.34	1.64	3.43	0.02	1.17	0.09	0.04	0.03	1.00	0.26	0.08	0.01	0.01	0.15
	Wood-stave planks	2	240	0.29	1.40	2.94	0.02	1.00	0.08	0.04	0.03	0.86	0.22	0.07	0.01	0.01	0.13
	Copco 2 Subtotal	127	418	1.29	6.17	12.91	0.08	4.40	0.34	0.17	0.13	3.77	0.97	0.31	0.04	0.06	0.57
Iron Gate	Earth	800	2	0.98	4.68	9.79	0.06	3.34	0.26	0.13	0.10	2.86	0.74	0.24	0.03	0.04	0.43
(California)	Concrete	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
	Metal	5	54	0.16	0.79	1.65	0.01	0.56	0.04	0.02	0.02	0.48	0.12	0.04	0.01	0.01	0.07
	Building Waste	5	54	0.16	0.79	1.65	0.01	0.56	0.04	0.02	0.02	0.48	0.12	0.04	0.01	0.01	0.07
	Iron Gate Subtotal	860	112	1.37	6.55	13.71	0.09	4.68	0.36	0.18	0.14	4.00	1.03	0.33	0.04	0.06	0.60
	Grand Total	**1,277**	**748**	**3.79**	**16.05**	**35.45**	**0.23**	**12.89**	**0.89**	**0.47**	**0.35**	**11.18**	**2.76**	**0.82**	**0.12**	**0.15**	**1.68**
	California Total	1047	656	3.09	14.82	31.03	0.20	10.58	0.81	0.40	0.32	9.05	2.34	0.75	0.10	0.14	1.36
	Oregon Total	230	92	0.70	1.23	4.42	0.03	2.30	0.08	0.07	0.03	2.13	0.42	0.07	0.02	0.01	0.32
	California %	82%	88%	82%	92%	88%	85%	82%	91%	85%	91%	81%	85%	91%	85%	91%	81%
	Oregon %	18%	12%	18%	8%	12%	15%	18%	9%	15%	9%	19%	15%	9%	15%	9%	19%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Key:

CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M2H. Mitigated Annual Haul Truck Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Road Conditions	Average
ADT	Average

		Annual	Round Trip	Annual Mitigated Emissions (tons per year) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	8,500	1	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Concrete	2,600	3	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Metal	430	44	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Building Waste	200	44	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	11,730	92	0.01	0.02	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.01
Copco 1 (California)	Concrete	4,000	2	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Metal	170	62	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	30	62	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	4,200	126	0.01	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Copco 2 (California)	Earth	90	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Concrete (dam)	400	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Concrete (plant)	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (dam)	45	62	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (plant)	145	56	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	60	56	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood-stave planks	45	240	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	785	418	0.01	0.04	0.08	0.00	0.03	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Iron Gate (California)	Earth	60,000	2	0.04	0.18	0.37	0.00	0.13	0.01	0.00	0.00	0.11	0.03	0.01	0.00	0.00	0.02
	Concrete	750	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	130	54	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	40	54	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	60,920	112	0.04	0.19	0.40	0.00	0.14	0.01	0.01	0.00	0.12	0.03	0.01	0.00	0.00	0.02
	Grand Total	**77,635**	**748**	**0.07**	**0.28**	**0.62**	**0.00**	**0.21**	**0.02**	**0.01**	**0.01**	**0.20**	**0.05**	**0.01**	**0.00**	**0.00**	**0.03**
	California Total	65,905	656	0.05	0.26	0.54	0.00	0.17	0.01	0.01	0.01	0.16	0.04	0.01	0.00	0.00	0.02
	Oregon Total	11,730	92	0.01	0.02	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.01
	California %	85%	88%	81%	92%	87%	85%	80%	91%	85%	90%	80%	84%	91%	85%	90%	80%
	Oregon %	15%	12%	19%	8%	13%	15%	20%	9%	15%	10%	20%	16%	9%	15%	10%	20%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Key:
CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M3A. Summary of Daily Mitigated Off-Road Construction Emissions (Alternative 3)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	36	225	63	2	3	3
Copco 1	18	130	51	1	2	2
Copco 2	13	51	29	1	1	1
J.C. Boyle	10	53	18	1	1	1
Total	77	458	161	4	7	7
California %	87%	88%	89%	87%	89%	89%
Oregon %	13%	12%	11%	13%	11%	11%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M3B. Summary of Annual Mitigated Off-Road Construction Emissions (Alternative 3)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	1.5	9.3	2.6	0.1	0.1	0.1
Copco 1	0.7	5.1	2.0	0.0	0.1	0.1
Copco 2	0.7	2.1	1.7	0.1	0.1	0.1
J.C. Boyle	0.8	2.9	1.3	0.1	0.1	0.1
Total	3.7	19.4	7.6	0.2	0.4	0.3
California %	79%	85%	83%	77%	81%	81%
Oregon %	21%	15%	17%	23%	19%	19%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M3C. Mitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 3)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.00	0.39	3.03	0.82	0.02	0.03	0.03	0.02	0.13	0.03	0.00	0.00	0.00
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.00	0.19	4.46	0.40	0.01	0.02	0.01	0.01	0.19	0.02	0.00	0.00	0.00
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX120	Excavators	646	Diesel	0.06	0.43	0.12	0.00	0.00	0.00	5.02	34.60	9.30	0.19	0.35	0.32	0.21	1.44	0.39	0.01	0.01	0.01
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.08	0.46	0.12	0.00	0.00	0.00	20.31	124.77	33.29	0.65	1.30	1.19	0.84	5.18	1.38	0.03	0.05	0.05
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.07	0.45	0.12	0.00	0.00	0.00	1.48	9.59	2.57	0.05	0.10	0.09	0.06	0.40	0.11	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.19	2.11	0.23	0.01	0.06	0.04	0.01	0.09	0.01	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.06	0.62	1.74	0.00	0.06	0.04	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.08	0.76	2.12	0.00	0.08	0.05	0.00	0.03	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.01	0.56	10.47	0.91	0.02	0.04	0.04	0.02	0.43	0.04	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.05	1.44	0.13	0.00	0.00	0.00	1.10	31.08	2.84	0.07	0.10	0.10	0.05	1.29	0.12	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	36.18	224.75	63.11	1.57	2.75	2.52
Total Annual 2020 (tpy)	1.50	9.33	2.62	0.07	0.11	0.10

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M3D. Mitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 3)

Maximum Daily Work Hours 8

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Quantity					2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.00	0.44	3.46	0.94	0.02	0.03	0.03	0.02	0.13	0.04	0.00	0.00	0.00
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.01	0.20	0.02	0.00	0.00	0.00
1	0	Excavator - hydraulic ram	321	Diesel	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.01	0.09	0.02	0.00	0.00	0.00
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	0.08	0.54	0.14	0.00	0.01	0.00	0.59	4.21	1.09	0.03	0.04	0.04	0.02	0.16	0.04	0.00	0.00	0.00
3	0	Excavator - <20,000 lb	168	Diesel	0.08	1.62	0.14	0.00	0.01	0.01	0.68	14.36	1.27	0.03	0.05	0.05	0.03	0.56	0.05	0.00	0.00	0.00
1	0	Loader - WA250 IT	138	Diesel	0.06	1.47	0.13	0.00	0.01	0.00	0.15	3.58	0.32	0.01	0.01	0.01	0.01	0.14	0.01	0.00	0.00	0.00
1	0	Loader - WA450	273	Diesel	0.05	0.38	0.10	0.00	0.00	0.00	0.23	1.82	0.49	0.01	0.02	0.02	0.01	0.07	0.02	0.00	0.00	0.00
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	0.08	0.46	0.12	0.00	0.00	0.00	0.87	5.33	1.42	0.03	0.06	0.05	0.03	0.21	0.06	0.00	0.00	0.00
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.66	7.32	0.79	0.02	0.21	0.15	0.03	0.29	0.03	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.22	2.15	6.05	0.01	0.22	0.16	0.01	0.08	0.24	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.27	2.62	7.37	0.02	0.27	0.19	0.01	0.10	0.29	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.99	10.93	1.18	0.03	0.32	0.22	0.04	0.43	0.05	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.01	0.63	11.97	1.04	0.02	0.04	0.04	0.02	0.47	0.04	0.00	0.00	0.00
1	1	Engine generator, 6.5 KW	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	106	Diesel	0.07	1.63	0.68	0.00	0.01	0.01	1.09	24.37	10.22	0.05	0.08	0.08	0.04	0.95	0.40	0.00	0.00	0.00
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	0.06	0.50	0.14	0.00	0.00	0.00	2.35	20.38	5.55	0.11	0.20	0.18	0.09	0.79	0.22	0.00	0.01	0.01
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	0.07	1.63	0.68	0.00	0.01	0.01	0.27	6.09	2.55	0.01	0.02	0.02	0.01	0.24	0.10	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	17.76	129.61	51.47	1.05	2.32	1.94
Total Annual 2020 (tpy)	0.69	5.05	2.01	0.04	0.09	0.08

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M3E. Mitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 3)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	9,989	904	8	0.04	0.29	0.08	0.00	0.00	0.00	0.22	1.73	0.47	0.01	0.02	0.02	0.01	0.10	0.03	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.01	0.30	0.03	0.00	0.00	0.00
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	16,200	1,200	8	0.06	0.39	0.10	0.00	0.00	0.00	0.64	4.39	1.18	0.02	0.04	0.04	0.02	0.16	0.04	0.00	0.00	0.00
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	24,372	1,808	8	0.06	0.39	0.10	0.00	0.00	0.00	0.64	4.39	1.18	0.02	0.04	0.04	0.04	0.25	0.07	0.00	0.00	0.00
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	0.06	0.49	0.13	0.00	0.00	0.00	0.52	4.25	1.12	0.03	0.04	0.04	0.04	0.29	0.08	0.00	0.00	0.00
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	0.05	0.38	0.10	0.00	0.00	0.00	0.39	3.17	0.86	0.02	0.03	0.03	0.00	0.03	0.01	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	7,702	928	8	0.08	0.46	0.12	0.00	0.00	0.00	1.11	6.80	1.81	0.04	0.07	0.07	0.03	0.20	0.05	0.00	0.00	0.00
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	0.07	0.56	0.15	0.00	0.01	0.00	0.30	2.33	0.61	0.01	0.02	0.02	0.01	0.07	0.02	0.00	0.00	0.00
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	1.64	15.84	44.50	0.10	1.61	1.14	0.11	1.07	3.01	0.01	0.11	0.08	0.01	0.07	0.21	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	1.64	15.84	44.50	0.10	1.61	1.14	0.07	0.65	1.84	0.00	0.07	0.05	0.00	0.04	0.13	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	0.10	1.94	0.17	0.00	0.01	0.01	0.32	5.98	0.52	0.01	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	1.14	3.03	14.06	0.93	1.00	0.97	0.78	2.08	9.67	0.64	0.69	0.67	0.05	0.14	0.66	0.04	0.05	0.05
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.50	0.16	0.25	0.01	0.02	0.02
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,572	728	8	0.07	1.63	0.68	0.00	0.01	0.01	0.08	1.72	0.72	0.00	0.01	0.01	0.00	0.08	0.03	0.00	0.00	0.00
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	4,193	1,456	8	0.07	1.63	0.68	0.00	0.01	0.01	0.21	4.60	1.93	0.01	0.02	0.01	0.01	0.21	0.09	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	12.85	50.61	29.08	1.03	1.44	1.34
Total Annual 2020 (tpy)	0.74	2.12	1.69	0.07	0.09	0.08

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M3F. Mitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 3)

Maximum Daily Work Hours 8 hours

Note: Emission calculations assume that construction equipment meet California emission standards for MY2015 and newer equipment

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	**Equipment Description**	**Fuel Type**	**OFFROAD Category**	**Rating (hp)**	**Fuel Amount (gal)**	**Total Hours**	**Hours**	**VOC**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**VOC**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**	**VOC**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Cranes	335	17,680	1,600	8	0.04	0.29	0.08	0.00	0.00	0.00	0.22	1.73	0.47	0.01	0.02	0.02	0.02	0.17	0.05	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Cranes	130	3,256	800	8	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.01	0.13	0.01	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000	Diesel	Excavators	321	9,612	712	8	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.01	0.10	0.03	0.00	0.00	0.00
2	Hydraulic excavator, 2.5 cy	Diesel	Excavators	321	51,332	3,808	8	0.06	0.39	0.10	0.00	0.00	0.00	0.64	4.39	1.18	0.02	0.04	0.04	0.08	0.52	0.14	0.00	0.01	0.00
1	Hydraulic excavator, 6 cy	Diesel	Excavators	513	11,014	488	8	0.06	0.43	0.12	0.00	0.00	0.00	0.57	3.92	1.06	0.02	0.04	0.04	0.02	0.12	0.03	0.00	0.00	0.00
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Rubber Tired Loaders	246	11,912	1,504	8	0.06	0.49	0.13	0.00	0.00	0.00	0.52	4.25	1.12	0.03	0.04	0.04	0.02	0.20	0.05	0.00	0.00	0.00
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Off-Highway Trucks	415	8,300	1,000	8	0.08	0.46	0.12	0.00	0.00	0.00	2.77	17.01	4.54	0.09	0.18	0.17	0.03	0.21	0.06	0.00	0.00	0.00
1	Crawler dozer, Cat238	Diesel	Crawler Tractors	238	9,280	1,000	8	0.07	0.56	0.15	0.00	0.01	0.01	0.30	2.33	0.61	0.01	0.02	0.02	0.02	0.15	0.04	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.03	0.02	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Off-Highway Trucks	175	12,582	2,104	8	0.10	1.94	0.17	0.00	0.01	0.01	0.32	5.98	0.52	0.01	0.02	0.02	0.04	0.79	0.07	0.00	0.00	0.00
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.03	0.09	0.43	0.03	0.03	0.03
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	9.79	3.16	4.99	0.27	0.33	0.31	3.63	1.17	1.85	0.10	0.12	0.11	0.43	0.14	0.22	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Other Construction Equipment	60	2,888	1,072	8	0.07	1.63	0.68	0.00	0.01	0.01	0.08	1.72	0.72	0.00	0.01	0.01	0.01	0.12	0.05	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Diesel	Other Construction Equipment	80	3,087	1,072	8	0.07	1.63	0.68	0.00	0.01	0.01	0.10	2.30	0.96	0.00	0.01	0.01	0.01	0.15	0.06	0.00	0.00	0.00

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	10.20	53.39	17.64	0.55	0.82	0.75
Total Annual 2020 (tpy)	0.76	2.95	1.27	0.05	0.07	0.06

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M3G. Mitigated Daily Haul Truck Emissions
Alternative 3 - Partial Facilities Removal

Road Conditions	Average
ADT	Average

Dam	Waste Material	Peak Daily Trips	Round Trip Distance (mi)	Daily Mitigated Emissions (lbs/day) - 2020													
				ROG	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle (Oregon)	Earth	160	1	0.09	0.17	0.59	0.00	0.31	0.01	0.01	0.00	0.29	0.06	0.01	0.00	0.00	0.04
	Concrete	50	3	0.09	0.16	0.56	0.00	0.29	0.01	0.01	0.00	0.27	0.05	0.01	0.00	0.00	0.04
	Metal	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	J.C. Boyle Subtotal	220	48	0.44	0.78	2.79	0.02	1.45	0.05	0.04	0.02	1.34	0.27	0.05	0.01	0.01	0.20
Copco 1 (California)	Concrete	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
	Metal	5	62	0.19	0.91	1.90	0.01	0.65	0.05	0.02	0.02	0.55	0.14	0.05	0.01	0.01	0.08
	Copco 1 Subtotal	55	64	0.25	1.20	2.51	0.02	0.86	0.07	0.03	0.03	0.73	0.19	0.06	0.01	0.01	0.11
Copco 2 (California)	Earth	0	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Concrete	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
	Metal	15	58	0.53	2.54	5.32	0.03	1.82	0.14	0.07	0.05	1.55	0.40	0.13	0.02	0.02	0.23
	Wood-stave planks	2	240	0.29	1.40	2.94	0.02	1.00	0.08	0.04	0.03	0.86	0.22	0.07	0.01	0.01	0.13
	Copco 2 Subtotal	67	302	0.88	4.24	8.87	0.06	3.03	0.23	0.12	0.09	2.59	0.67	0.21	0.03	0.04	0.39
Iron Gate (California)	Earth	800	2	0.98	4.68	9.79	0.06	3.34	0.26	0.13	0.10	2.86	0.74	0.24	0.03	0.04	0.43
	Concrete	50	2	0.06	0.29	0.61	0.00	0.21	0.02	0.01	0.01	0.18	0.05	0.01	0.00	0.00	0.03
	Metal	5	54	0.16	0.79	1.65	0.01	0.56	0.04	0.02	0.02	0.48	0.12	0.04	0.01	0.01	0.07
	Iron Gate Subtotal	855	58	1.20	5.76	12.06	0.08	4.11	0.32	0.16	0.12	3.52	0.91	0.29	0.04	0.05	0.53
	Grand Total	**1,197**	**472**	**2.77**	**11.97**	**26.22**	**0.17**	**9.45**	**0.66**	**0.35**	**0.26**	**8.18**	**2.03**	**0.61**	**0.09**	**0.11**	**1.23**
	California Total	977	424	2.34	11.19	23.44	0.15	7.99	0.61	0.30	0.24	6.84	1.77	0.56	0.08	0.10	1.03
	Oregon Total	220	48	0.44	0.78	2.79	0.02	1.45	0.05	0.04	0.02	1.34	0.27	0.05	0.01	0.01	0.20
	California %	82%	90%	84%	94%	89%	88%	85%	93%	87%	92%	84%	87%	93%	87%	92%	84%
	Oregon %	18%	10%	16%	6%	11%	12%	15%	7%	13%	8%	16%	13%	7%	13%	8%	16%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Notes:

1. Peak daily trips assumed to be the same as Alternative 2 unless a material (e.g., earth at Copco 2) is not disposed during Alternative 3.
2. Waste disposal quantities for building waste not provided for Alternative 3; therefore, buildings were not assumed to be demolished during this alternative.

Key:

CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M3H. Mitigated Annual Haul Truck Emissions
Alternative 3 - Partial Facilities Removal

Road Conditions	Average
ADT	Average

		Annual	Round Trip	Annual Mitigated Emissions (tons per year) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	8,500	1	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Concrete	1,300	3	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	255	44	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	10,055	48	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Copco 1	Concrete	3,710	2	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
(California)	Metal	65	62	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	3,775	64	0.00	0.02	0.04	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Copco 2	Earth	0	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(California)	Concrete	150	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	50	58	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood-stave planks	45	240	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	245	302	0.00	0.02	0.04	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Iron Gate	Earth	60,000	2	0.04	0.18	0.37	0.00	0.13	0.01	0.00	0.00	0.11	0.03	0.01	0.00	0.00	0.02
(California)	Concrete	500	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	75	54	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	60,575	58	0.04	0.18	0.38	0.00	0.13	0.01	0.00	0.00	0.11	0.03	0.01	0.00	0.00	0.02
	Grand Total	**74,650**	**472**	**0.05**	**0.23**	**0.50**	**0.00**	**0.18**	**0.01**	**0.01**	**0.01**	**0.16**	**0.04**	**0.01**	**0.00**	**0.00**	**0.02**
	California Total	64,595	424	0.05	0.22	0.46	0.00	0.16	0.01	0.01	0.00	0.13	0.03	0.01	0.00	0.00	0.02
	Oregon Total	10,055	48	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	California %	87%	90%	87%	95%	91%	90%	87%	94%	90%	94%	86%	89%	94%	90%	94%	86%
	Oregon %	13%	10%	13%	5%	9%	10%	13%	6%	10%	6%	14%	11%	6%	10%	6%	14%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Note:

Annual trips estimated from ratio of the quantity of waste disposed during Alternative 3 as compared to Alternative 2.

Key:

CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M4A. Summary of Daily Mitigated Off-Road Construction Emissions (Alternative 5)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	36	225	63	2	3	3
Copco 1	18	130	51	1	2	2
Copco 2	6	48	26	0	1	1
J.C. Boyle	6	45	16	0	1	1
Total	66	447	157	3	7	6
California %	91%	90%	90%	87%	89%	90%
Oregon %	9%	10%	10%	13%	11%	10%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M4B. Summary of Annual Mitigated Off-Road Construction Emissions (Alternative 5)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	1.5	9.3	2.6	0.1	0.1	0.1
Copco 1	0.7	5.1	2.0	0.0	0.1	0.1
Copco 2	0.1	0.7	0.4	0.0	0.0	0.0
J.C. Boyle	0.2	1.4	0.6	0.0	0.0	0.0
Total	2.5	16.4	5.6	0.1	0.3	0.2
California %	91%	92%	90%	86%	88%	88%
Oregon %	9%	8%	10%	14%	12%	12%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M4C. Mitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 5)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.00	0.39	3.03	0.82	0.02	0.03	0.03	0.02	0.13	0.03	0.00	0.00	0.00
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.00	0.19	4.46	0.40	0.01	0.02	0.01	0.01	0.19	0.02	0.00	0.00	0.00
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX120	Excavators	646	Diesel	0.06	0.43	0.12	0.00	0.00	0.00	5.02	34.60	9.30	0.19	0.35	0.32	0.21	1.44	0.39	0.01	0.01	0.01
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.08	0.46	0.12	0.00	0.00	0.00	20.31	124.77	33.29	0.65	1.30	1.19	0.84	5.18	1.38	0.03	0.05	0.05
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.07	0.45	0.12	0.00	0.00	0.00	1.48	9.59	2.57	0.05	0.10	0.09	0.06	0.40	0.11	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.19	2.11	0.23	0.01	0.06	0.04	0.01	0.09	0.01	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.06	0.62	1.74	0.00	0.06	0.04	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.08	0.76	2.12	0.00	0.08	0.05	0.00	0.03	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.01	0.56	10.47	0.91	0.02	0.04	0.04	0.02	0.43	0.04	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.05	1.44	0.13	0.00	0.00	0.00	1.10	31.08	2.84	0.07	0.10	0.10	0.05	1.29	0.12	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	36.18	224.75	63.11	1.57	2.75	2.52
Total Annual 2020 (tpy)	1.50	9.33	2.62	0.07	0.11	0.10

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M4D. Mitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 5)

Maximum Daily Work Hours 8

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Quantity Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources) ROG	CO	NOx	SOx	PM10	PM2.5	Peak Daily Emissions (lbs/day) ROG	CO	NOx	SO2	PM10	PM2.5	2020 Emissions (tons per year) ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	335	Diesel	0.04	0.29	0.08	0.00	0.00	0.00	0.44	3.46	0.94	0.02	0.03	0.03	0.02	0.13	0.04	0.00	0.00	0.00
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.01	0.20	0.02	0.00	0.00	0.00
1	0	Excavator - hydraulic ram	321	Diesel	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.01	0.09	0.02	0.00	0.00	0.00
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	0.08	0.54	0.14	0.00	0.01	0.00	0.59	4.21	1.09	0.03	0.04	0.04	0.02	0.16	0.04	0.00	0.00	0.00
3	0	Excavator - <20,000 lb	168	Diesel	0.08	1.62	0.14	0.00	0.01	0.01	0.68	14.36	1.27	0.03	0.05	0.05	0.03	0.56	0.05	0.00	0.00	0.00
1	0	Loader - WA250 IT	138	Diesel	0.06	1.47	0.13	0.00	0.01	0.00	0.15	3.58	0.32	0.01	0.01	0.01	0.01	0.14	0.01	0.00	0.00	0.00
1	0	Loader - WA450	273	Diesel	0.05	0.38	0.10	0.00	0.00	0.00	0.23	1.82	0.49	0.01	0.02	0.02	0.01	0.07	0.02	0.00	0.00	0.00
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	0.08	0.46	0.12	0.00	0.00	0.00	0.87	5.33	1.42	0.03	0.06	0.05	0.03	0.21	0.06	0.00	0.00	0.00
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.66	7.32	0.79	0.02	0.21	0.15	0.03	0.29	0.03	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.22	2.15	6.05	0.01	0.22	0.16	0.01	0.08	0.24	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	1.64	15.84	44.50	0.10	1.61	1.14	0.27	2.62	7.37	0.02	0.27	0.19	0.01	0.10	0.29	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	2.59	28.49	3.08	0.09	0.83	0.57	0.99	10.93	1.18	0.03	0.32	0.22	0.04	0.43	0.05	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	0.10	1.94	0.17	0.00	0.01	0.01	0.63	11.97	1.04	0.02	0.04	0.04	0.02	0.47	0.04	0.00	0.00	0.00
1	1	Engine generator, 6.5 KW	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	106	Diesel	0.07	1.63	0.68	0.00	0.01	0.01	1.09	24.37	10.22	0.05	0.08	0.08	0.04	0.95	0.40	0.00	0.00	0.00
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	0.06	0.50	0.14	0.00	0.00	0.00	2.35	20.38	5.55	0.11	0.20	0.18	0.09	0.79	0.22	0.00	0.01	0.01
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	0.07	1.63	0.68	0.00	0.01	0.01	0.27	6.09	2.55	0.01	0.02	0.02	0.01	0.24	0.10	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	17.76	129.61	51.47	1.05	2.32	1.94
Total Annual 2020 (tpy)	0.69	5.05	2.01	0.04	0.09	0.08

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M4E. Mitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 5)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	4,862	440	8	0.04	0.29	0.08	0.00	0.00	0.00	0.22	1.73	0.47	0.01	0.02	0.02	0.01	0.05	0.01	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	2,670	656	8	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.00	0.10	0.01	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	1,512	112	8	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.00	0.02	0.00	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	4,421	328	8	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.01	0.04	0.01	0.00	0.00	0.00
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	2,598	328	8	0.06	0.49	0.13	0.00	0.00	0.00	0.26	2.13	0.56	0.01	0.02	0.02	0.01	0.04	0.01	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	3,718	448	8	0.08	0.46	0.12	0.00	0.00	0.00	1.11	6.80	1.81	0.04	0.07	0.07	0.02	0.10	0.03	0.00	0.00	0.00
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	1,039	112	8	0.07	0.56	0.15	0.00	0.01	0.00	0.30	2.33	0.61	0.01	0.02	0.02	0.00	0.02	0.00	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	845	440	8	1.64	15.84	44.50	0.10	1.61	1.14	0.06	0.54	1.51	0.00	0.05	0.04	0.00	0.01	0.04	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	1,030	440	8	1.64	15.84	44.50	0.10	1.61	1.14	0.07	0.65	1.84	0.00	0.07	0.05	0.00	0.02	0.05	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	1,340	224	8	0.10	1.94	0.17	0.00	0.01	0.01	0.32	5.98	0.52	0.01	0.02	0.02	0.00	0.08	0.01	0.00	0.00	0.00
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	5,709	704	8	0.04	0.39	0.11	0.00	0.00	0.00	0.68	6.44	1.76	0.04	0.06	0.06	0.01	0.07	0.02	0.00	0.00	0.00
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	263	112	8	0.05	1.44	0.13	0.00	0.00	0.00	0.12	3.49	0.32	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	280	400	8	1.14	3.03	14.06	0.93	1.00	0.97	0.26	0.69	3.22	0.21	0.23	0.22	0.01	0.02	0.08	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	242	112	8	0.07	1.63	0.68	0.00	0.01	0.01	0.08	1.72	0.72	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	323	112	8	0.07	1.63	0.68	0.00	0.01	0.01	0.10	2.30	0.96	0.00	0.01	0.01	0.00	0.02	0.01	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	2,822	224	8	1.64	15.84	44.50	0.10	1.61	1.14	0.36	3.52	9.89	0.02	0.36	0.25	0.01	0.05	0.14	0.00	0.00	0.00
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	112	800	8	9.79	3.16	4.99	0.27	0.33	0.30	0.95	0.31	0.48	0.03	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	5.74	48.13	26.32	0.44	1.04	0.87
Total Annual 2020 (tpy)	0.1	0.7	0.4	0.0	0.0	0.0

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M4F. Mitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 5)

Maximum Daily Work Hours 8 hours

Note: Emission calculations assume that construction equipment meet California emission standards for MY2015 and newer equipment

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	Fuel Type	OFFROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Hours	VOC	CO	NOx	SOx	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Cranes	335	10,696	968	8	0.04	0.29	0.08	0.00	0.00	0.00	0.22	1.73	0.47	0.01	0.02	0.02	0.01	0.10	0.03	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Cranes	130	5,926	1,456	8	0.05	1.11	0.10	0.00	0.00	0.00	0.22	5.10	0.46	0.01	0.02	0.02	0.01	0.23	0.02	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000	Diesel	Excavators	321	3,240	240	8	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.00	0.03	0.01	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Diesel	Excavators	321	9,813	728	8	0.06	0.39	0.10	0.00	0.00	0.00	0.32	2.19	0.59	0.01	0.02	0.02	0.01	0.10	0.03	0.00	0.00	0.00
1	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Rubber Tired Loaders	246	5,766	728	8	0.06	0.49	0.13	0.00	0.00	0.00	0.26	2.13	0.56	0.01	0.02	0.02	0.01	0.10	0.03	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Off-Highway Trucks	415	8,101	976	8	0.08	0.46	0.12	0.00	0.00	0.00	1.11	6.80	1.81	0.04	0.07	0.07	0.03	0.21	0.06	0.00	0.00	0.00
1	Crawler dozer, Cat238	Diesel	Crawler Tractors	238	2,227	240	8	0.07	0.56	0.15	0.00	0.01	0.01	0.30	2.33	0.61	0.01	0.02	0.02	0.00	0.03	0.01	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	1,859	968	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	2,265	968	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.02	0.01	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Off-Highway Trucks	175	2,918	488	8	0.10	1.94	0.17	0.00	0.01	0.01	0.32	5.98	0.52	0.01	0.02	0.02	0.01	0.18	0.02	0.00	0.00	0.00
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Diesel	Other Construction Equipment	235	12,455	1,536	8	0.04	0.39	0.11	0.00	0.00	0.00	0.68	6.44	1.76	0.04	0.06	0.06	0.02	0.15	0.04	0.00	0.00	0.00
1	Compactor, Cat, vibratory, self propelled, 84"	Diesel	Rollers	138	564	240	8	0.05	1.44	0.13	0.00	0.00	0.00	0.12	3.49	0.32	0.01	0.01	0.01	0.00	0.05	0.00	0.00	0.00	0.00
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	610	872	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.01	0.04	0.18	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Other Construction Equipment	60	647	240	8	0.07	1.63	0.68	0.00	0.01	0.01	0.08	1.72	0.72	0.00	0.01	0.01	0.00	0.03	0.01	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Diesel	Other Construction Equipment	80	691	240	8	0.07	1.63	0.68	0.00	0.01	0.01	0.10	2.30	0.96	0.00	0.01	0.01	0.00	0.03	0.01	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	Diesel	N/A - MOBILE	450	6,149	488	8	2.06	3.65	13.08	0.10	0.53	0.30	0.46	0.81	2.91	0.02	0.12	0.07	0.01	0.02	0.09	0.00	0.00	0.00
2	Portable generator 1 KW	Gasoline	N/A - AP42 3.3-1	2.75	244	1,744	8	9.79	3.16	4.99	0.27	0.33	0.31	0.95	0.31	0.48	0.03	0.03	0.03	0.05	0.02	0.03	0.00	0.00	0.00

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	5.98	44.82	16.34	0.44	0.73	0.63
Total Annual 2020 (tpy)	0.22	1.37	0.57	0.02	0.03	0.03

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:

Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M5A. Summary of EMFAC2007 Emission Factors (Mitigated)

	Emission Factors (g/mi) - 2020													
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Construction Workers	0.202	0.235	4.201	0.439	0.004	0.041	0.021	0.008	0.013	0.026	0.019	0.002	0.005	455.772	0.030
Pick-up Trucks (Gasoline)	0.148	0.166	1.627	0.176	0.005	0.048	0.027	0.008	0.013	0.032	0.025	0.002	0.005	503.223	0.017
Pick-up Trucks (Diesel)	0.056	0.064	0.543	1.526	0.003	0.055	0.035	0.008	0.013	0.039	0.032	0.002	0.005	345.726	0.003
Heavy-Duty Diesel Trucks	0.277	0.315	1.325	2.776	0.018	0.137	0.073	0.036	0.028	0.088	0.067	0.009	0.012	1878.225	0.013

	Emission Factors (g/gal) - 2020													
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	2.588	2.900	28.488	3.079	0.085	0.834	0.474	0.140	0.220	0.569	0.440	0.035	0.094	8813.455	0.301
Pick-up Trucks (Diesel)	1.637	1.863	15.842	44.502	0.096	1.607	1.008	0.233	0.366	1.142	0.927	0.058	0.157	10079.999	0.076
Heavy-Duty Gasoline Vehicles	7.368	8.928	539.818	71.403	0.085	0.722	0.178	0.162	0.382	0.573	0.041	0.164	0.369	7987.455	1.462
Heavy-Duty Diesel Trucks	1.485	1.690	7.113	14.897	0.096	0.734	0.390	0.193	0.151	0.472	0.358	0.048	0.065	10079.997	0.069

Notes:

Construction workers emissions only include LDA, LDT1, and LDT2 vehicle types, based on guidance from URBEMIS2007 User's Guide.

CO2 emission factors for construction workers adjusted to reflect the Pavley and LCFS using CARB's Pavley post-processor.

Pick-up trucks use LDT2 emission factors.

Key:

CH4 = methane
CO = carbon monoxide
CO2 = carbon dioxide
g/mi = grams per mile
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
TOG = total organic gases

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Table M6A. Summary of Daily Unmitigated Emissions

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Grand Total						
Alternative 2	131	584	650	9	503	248
Alternative 3	128	570	625	9	484	244
Alternative 4	11	63	59	4	11	6
Alternative 5	117	552	620	7	399	225
Threshold	250	2,500	250	250	250	250

Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M6B. Alternative 2 Daily Unmitigated Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	63	248	313	2	12	11
Haul Trucks	3	12	34	0	5	2
Employee Commuting	1	11	1	0	4	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	157	33
TOTAL	67	272	348	2	210	50
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	4	11	0	2	1
Employee Commuting	1	13	1	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	161	159
TOTAL	27	176	129	1	174	165
Copco 2						
Construction Equipment	19	56	80	1	4	3
Haul Trucks	3	12	32	0	5	2
Employee Commuting	1	16	2	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	4	0
Fugitive Dust - Materials	--	--	--	--	3	1
TOTAL	22	83	113	1	17	6
JC Boyle						
Construction Equipment	13	22	54	5	9	8
Haul Trucks	1	1	4	0	2	0
Employee Commuting	2	31	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	5	1
Fugitive Dust - Materials	--	--	--	--	84	17
TOTAL	15	54	60	5	103	27
Grand Total	131	584	650	9	503	248
California Total	116	531	590	4	401	221
Oregon Total	15	54	60	5	103	27

Peak Daily	104	409	521	8	330	83
California Total	89	355	461	3	227	56
Oregon Total	15	54	60	5	103	27

Note:
Peak daily emissions do not include Copco 1.
Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M6C. Alternative 3 Daily Unmitigated Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	63	248	313	2	12	11
Haul Trucks	2	11	30	0	5	1
Employee Commuting	1	11	1	0	4	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	156	33
TOTAL	66	270	344	2	208	49
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	2	6	0	1	0
Employee Commuting	1	11	1	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	159	158
TOTAL	27	173	124	1	171	165
Copco 2						
Construction Equipment	19	56	80	1	4	3
Haul Trucks	2	8	22	0	3	1
Employee Commuting	1	16	2	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	21	80	103	1	12	5
J.C. Boyle						
Construction Equipment	12	19	49	5	8	7
Haul Trucks	0	1	3	0	1	0
Employee Commuting	1	28	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	5	1
Fugitive Dust - Materials	--	--	--	--	77	16
TOTAL	14	48	53	5	94	25
Grand Total	128	570	625	9	484	244
California Total	115	522	571	4	390	219
Oregon Total	14	48	53	5	94	25

Peak Daily	101	397	500	8	314	79
California Total	88	349	447	3	220	54
Oregon Total	14	48	53	5	94	25

Note:
Peak daily emissions do not include Copco 1.
Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M6D. Alternative 4 Unmitigated Daily Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate	**2023**					
Construction Equipment	10	54	52	0	2	2
Haul Trucks	1	3	7	0	1	0
Employee Commuting	1	6	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	2	0
TOTAL	11	63	59	0	8	3
Copco 1	**2025**					
Construction Equipment	9	51	37	0	2	1
Haul Trucks	1	3	7	0	2	0
Employee Commuting	1	4	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	10	58	45	0	5	2
Copco 2	**2024**					
Construction Equipment	9	51	42	0	2	2
Haul Trucks	1	3	8	0	2	0
Employee Commuting	0	3	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	10	58	50	0	5	2
J.C. Boyle	**2022**					
Construction Equipment	8	14	45	3	6	5
Haul Trucks	1	1	5	0	3	1
Employee Commuting	0	0	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	9	16	50	4	11	6
Maximum Daily Emissions	11	63	59	4	11	6

Key:
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M6E. Alternative 5 Unmitigated Daily Emissions Summary (pounds per day)

	Peak Daily Emissions (lb/day)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	63	248	313	2	12	11
Haul Trucks	2	11	30	0	5	1
Employee Commuting	1	22	2	0	5	1
Fugitive Dust - Unpaved Roads	--	--	--	--	31	3
Fugitive Dust - Materials	--	--	--	--	157	33
TOTAL	67	282	345	2	209	49
Copco 1						
Construction Equipment	26	159	117	1	6	5
Haul Trucks	1	4	11	0	2	1
Employee Commuting	1	16	2	0	3	1
Fugitive Dust - Unpaved Roads	--	--	--	--	2	0
Fugitive Dust - Materials	--	--	--	--	160	159
TOTAL	28	179	129	1	173	165
Copco 2						
Construction Equipment	11	52	70	0	3	3
Haul Trucks	1	4	12	0	2	1
Employee Commuting	0	4	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	12	61	82	0	6	4
J.C. Boyle						
Construction Equipment	8	18	56	4	6	6
Haul Trucks	1	2	6	0	3	1
Employee Commuting	1	12	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	1	0
TOTAL	10	32	63	4	11	7
Grand Total	117	552	620	7	399	225
California Total	107	521	557	3	388	218
Oregon Total	10	32	63	4	11	7

Peak Daily	89	374	490	6	226	60
California Total	79	342	428	2	215	53
Oregon Total	10	32	63	4	11	7

Note:
Peak daily emissions do not include Copco 1.
CO = carbon monoxide
lb/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M6F. Summary of Unmitigated Annual Emissions

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Alternative 2	6	24	28	1	20	11
Alternative 3	6	23	26	0	20	11
Alternative 4	2	10	5	0	2	1
Alternative 5	4	20	22	0	18	10

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M6G. Alternative 2 Unmitigated Annual Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	3	10	13	0	1	0
Haul Trucks	0	0	1	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	3	11	14	0	10	2
Copco 1						
Construction Equipment	1	6	5	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	7	5	0	8	7
Copco 2						
Construction Equipment	1	3	4	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	3	5	0	0	0
JC Boyle						
Construction Equipment	1	2	5	0	1	1
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	2	0
TOTAL	1	3	5	0	3	1
Project Total	6	24	28	1	20	11
California Total	5	21	23	0	18	10
Oregon Total	1	3	5	0	3	1

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M6H. Alternative 3 Unmitigated Annual Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	3	10	13	0	1	0
Haul Trucks	0	0	1	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	3	11	14	0	10	2
Copco 1						
Construction Equipment	1	6	5	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	7	5	0	7	7
Copco 2						
Construction Equipment	1	2	4	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	3	4	0	0	0
J.C. Boyle						
Construction Equipment	1	1	3	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	2	0
TOTAL	1	2	3	0	2	1
Project Total	6	23	26	0	20	11
California Total	5	21	23	0	17	10
Oregon Total	1	2	3	0	2	1

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M6I. Alternative 4 Unmitigated Annual Emissions Summary (tons per year)

	Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate	**2023**					
Construction Equipment	1	4	4	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	1	6	1	0	2	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	2	10	5	0	2	1
Copco 1	**2025**					
Construction Equipment	1	3	3	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	1	4	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	7	3	0	2	0
Copco 2	**2024**					
Construction Equipment	0	1	1	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	3	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	1	4	1	0	1	0
J.C. Boyle	**2022**					
Construction Equipment	0	0	1	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	1	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	0	0	2	0	1	0
Maximum	2	10	5	0	2	1

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M6J. Alternative 5 Unmitigated Annual Emissions Summary (tons per year)

	2020 Annual Emissions (tpy)					
	ROG	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Iron Gate						
Construction Equipment	3	10	13	0	1	0
Haul Trucks	0	0	1	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	1	0
Fugitive Dust - Materials	--	--	--	--	8	2
TOTAL	3	12	14	0	10	2
Copco 1						
Construction Equipment	1	6	5	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	1	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	0	0
Fugitive Dust - Materials	--	--	--	--	7	7
TOTAL	1	7	5	0	8	7
Copco 2						
Construction Equipment	0	1	1	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	0	1	1	0	0	0
J.C. Boyle						
Construction Equipment	0	1	2	0	0	0
Haul Trucks	0	0	0	0	0	0
Employee Commuting	0	0	0	0	0	0
Fugitive Dust - Unpaved Roads	--	--	--	--	--	--
Fugitive Dust - Materials	--	--	--	--	0	0
TOTAL	0	1	2	0	0	0
Project Total	4	20	22	0	18	10
California Total	4	19	20	0	17	10
Oregon Total	0	1	2	0	0	0

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides
tpy = tons per year

Table M7A. Summary of Daily Unmitigated Off-Road Construction Emissions (Alternative 2)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	63	248	313	2	12	11
Copco 1	26	159	117	1	6	5
Copco 2	19	56	80	1	4	3
J.C. Boyle	13	22	54	5	9	8
Total	121	485	564	9	30	28
California %	90%	96%	90%	41%	72%	71%
Oregon %	10%	4%	10%	59%	28%	29%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M7B. Summary of Annual Unmitigated Off-Road Construction Emissions (Alternative 2)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	2.6	10.3	13.0	0.1	0.5	0.5
Copco 1	1.0	6.2	4.6	0.0	0.2	0.2
Copco 2	1.1	2.8	4.2	0.1	0.2	0.2
J.C. Boyle	1.1	1.9	4.6	0.4	0.6	0.6
Total	5.8	21.3	26.5	0.6	1.6	1.5
California %	81%	91%	82%	31%	59%	59%
Oregon %	19%	9%	18%	69%	41%	41%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M7C. Unmitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 2)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.02	3.60	6.59	0.02	0.24	0.22	0.04	0.15	0.27	0.00	0.01	0.01
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.67	4.94	4.22	0.01	0.23	0.21	0.03	0.21	0.18	0.00	0.01	0.01
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX1200	Excavators	646	Diesel	0.12	0.46	0.61	0.00	0.02	0.02	9.60	36.68	49.01	0.19	1.77	1.63	0.40	1.52	2.03	0.01	0.07	0.07
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	36.27	132.59	182.31	0.65	6.66	6.13	1.51	5.50	7.57	0.03	0.28	0.25
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.21	0.84	1.53	0.00	0.06	0.06	4.45	18.05	32.69	0.05	1.31	1.20	0.18	0.75	1.36	0.00	0.05	0.05
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.20	4.38	0.54	0.01	0.07	0.05	0.01	0.18	0.02	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.09	0.72	1.69	0.00	0.08	0.06	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.11	0.87	2.06	0.00	0.10	0.08	0.00	0.04	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.17	10.55	6.39	0.02	0.33	0.30	0.05	0.44	0.27	0.00	0.01	0.01
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.14	1.52	0.89	0.00	0.04	0.04	2.93	32.78	19.12	0.07	0.92	0.90	0.12	1.36	0.79	0.00	0.04	0.04

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	63.33	248.42	313.49	1.56	12.32	11.37
Total Annual 2020 (tpy)	2.6	10.3	13.0	0.1	0.5	0.5

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M7D. Unmitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 2)

Maximum Daily Work Hours	8
Dam Removal Duration	
Start Date	12/30/2019
End Date	4/15/2020
	78

Quantity						2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Primary	Secondary	Equipment Description	OFFROAD Category	Rating (hp)	Fuel	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.17	4.11	7.54	0.02	0.28	0.25	0.05	0.16	0.29	0.00	0.01	0.01
1	1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.03	0.22	0.19	0.00	0.01	0.01
1	0	Excavator - hydraulic ram	Excavators	321	Diesel	0.11	0.42	0.55	0.00	0.02	0.02	0.62	2.36	3.10	0.01	0.11	0.10	0.02	0.09	0.12	0.00	0.00	0.00
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	Excavators	219.5	Diesel	0.15	0.59	0.82	0.00	0.03	0.03	1.16	4.60	6.31	0.03	0.22	0.20	0.05	0.18	0.25	0.00	0.01	0.01
3	0	Excavator - <20,000 lb	Excavators	168	Diesel	0.18	1.72	1.00	0.00	0.05	0.05	1.62	15.28	8.91	0.03	0.45	0.41	0.06	0.60	0.35	0.00	0.02	0.02
1	0	Loader - WA250 IT	Rubber Tired Loaders	138	Diesel	0.20	1.61	1.22	0.00	0.07	0.06	0.48	3.92	2.96	0.01	0.16	0.15	0.02	0.15	0.12	0.00	0.01	0.01
1	0	Loader - WA450	Rubber Tired Loaders	273	Diesel	0.12	0.45	0.73	0.00	0.03	0.02	0.57	2.19	3.50	0.01	0.13	0.12	0.02	0.09	0.14	0.00	0.00	0.00
2	0	Dump truck - articulated, 30 ton, Cat 730	Off-Highway Trucks	325	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	1.55	5.66	7.78	0.03	0.28	0.26	0.06	0.22	0.30	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.71	15.18	1.89	0.02	0.23	0.16	0.03	0.59	0.07	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.32	2.49	5.86	0.01	0.29	0.22	0.01	0.10	0.23	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.39	3.03	7.14	0.02	0.35	0.27	0.02	0.12	0.28	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	1.06	22.67	2.82	0.03	0.35	0.24	0.04	0.88	0.11	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.34	12.05	7.30	0.02	0.37	0.34	0.05	0.47	0.28	0.00	0.01	0.01
1	1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	Other Construction Equipment	106	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	2.83	28.69	21.67	0.05	1.12	1.10	0.11	1.12	0.85	0.00	0.04	0.04
4	4	Drills - air/hydraulic track, jackleg, or sinker	Bore/Drill Rigs	291	Diesel	0.07	0.50	0.24	0.00	0.01	0.01	2.91	20.51	9.75	0.11	0.27	0.25	0.11	0.80	0.38	0.00	0.01	0.01
2	2	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	53	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	0.71	7.17	5.42	0.01	0.28	0.27	0.03	0.28	0.21	0.00	0.01	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	25.97	159.30	116.91	1.05	5.85	5.27
Total Annual 2020 (tpy)	1.01	6.21	4.56	0.04	0.23	0.21

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M7E. Unmitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 2)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	12,111	1,096	8	0.10	0.35	0.64	0.00	0.02	0.02	0.58	2.06	3.77	0.01	0.14	0.13	0.04	0.14	0.26	0.00	0.01	0.01
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.05	0.34	0.29	0.00	0.02	0.01
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	24,408	1,808	8	0.11	0.42	0.55	0.00	0.02	0.02	1.23	4.71	6.20	0.02	0.23	0.21	0.07	0.27	0.35	0.00	0.01	0.01
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	29,548	2,192	8	0.11	0.42	0.55	0.00	0.02	0.02	1.23	4.71	6.20	0.02	0.23	0.21	0.08	0.32	0.42	0.00	0.02	0.01
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	0.15	0.57	1.02	0.00	0.04	0.03	1.33	4.97	8.86	0.03	0.30	0.28	0.09	0.34	0.61	0.00	0.02	0.02
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	0.12	0.45	0.73	0.00	0.03	0.02	0.99	3.81	6.08	0.02	0.22	0.20	0.01	0.03	0.05	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	11,686	1,408	8	0.14	0.49	0.68	0.00	0.02	0.02	1.98	7.23	9.94	0.04	0.36	0.33	0.09	0.32	0.44	0.00	0.02	0.01
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	0.22	0.72	1.57	0.00	0.06	0.05	0.90	3.02	6.57	0.01	0.24	0.22	0.03	0.10	0.21	0.00	0.01	0.01
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	2.34	18.31	43.09	0.10	2.11	1.61	0.16	1.24	2.92	0.01	0.14	0.11	0.01	0.08	0.20	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	2.34	18.31	43.09	0.10	2.11	1.61	0.10	0.76	1.78	0.00	0.09	0.07	0.01	0.05	0.12	0.00	0.01	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	0.22	1.95	1.18	0.00	0.06	0.06	0.67	6.03	3.65	0.01	0.19	0.17	0.00	0.01	0.01	0.00	0.00	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	1.14	3.03	14.06	0.93	1.00	0.97	0.78	2.08	9.67	0.64	0.69	0.67	0.05	0.14	0.66	0.04	0.05	0.05
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.50	0.16	0.25	0.01	0.02	0.02
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	2,367	1,096	8	0.19	1.92	1.45	0.00	0.08	0.07	0.20	2.03	1.53	0.00	0.08	0.08	0.01	0.14	0.11	0.00	0.01	0.01
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	6,313	2,192	8	0.19	1.92	1.45	0.00	0.08	0.07	0.53	5.41	4.09	0.01	0.21	0.21	0.04	0.37	0.28	0.00	0.01	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	18.71	56.05	79.77	1.03	3.62	3.36
Total Annual 2020 (tpy)	1.07	2.81	4.25	0.07	0.20	0.19

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M7F. Unmitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 2)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Hours	VOC	CO	NOx	SOx	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	23,603	2,136	8	0.07	0.21	0.79	0.04	0.06	0.06	0.43	1.23	4.64	0.24	0.37	0.35	0.06	0.16	0.62	0.03	0.05	0.05
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	3,256	800	8	0.07	0.14	0.48	0.04	0.07	0.06	0.32	0.62	2.19	0.18	0.31	0.29	0.01	0.02	0.05	0.00	0.01	0.01
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 f	Diesel	Diesel Excavators	321	57,672	4,272	8	0.09	0.22	0.59	0.05	0.09	0.08	0.98	2.53	6.65	0.59	0.99	0.93	0.13	0.34	0.89	0.08	0.13	0.12
2	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	57,587	4,272	8	0.09	0.22	0.59	0.05	0.09	0.08	0.98	2.53	6.65	0.59	0.99	0.93	0.13	0.34	0.89	0.08	0.13	0.12
1	Hydraulic excavator, 6 cy	Diesel	Diesel Excavators	513	11,014	488	8	0.09	0.22	0.59	0.05	0.09	0.08	0.78	2.02	5.32	0.47	0.79	0.75	0.02	0.06	0.16	0.01	0.02	0.02
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	11,912	1,504	8	0.09	0.18	0.56	0.05	0.09	0.08	0.79	1.55	4.84	0.45	0.76	0.71	0.04	0.07	0.23	0.02	0.04	0.03
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	16,600	2,000	8	0.08	0.12	0.31	0.05	0.08	0.07	3.04	4.22	11.32	1.81	2.83	2.65	0.08	0.11	0.28	0.05	0.07	0.07
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	9,280	1,000	8	0.09	0.12	0.40	0.05	0.08	0.08	0.36	0.51	1.67	0.21	0.34	0.31	0.02	0.03	0.10	0.01	0.02	0.02
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.03	0.02	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	12,582	2,104	8	0.08	0.09	0.19	0.05	0.07	0.07	0.25	0.27	0.60	0.15	0.23	0.22	0.03	0.04	0.08	0.02	0.03	0.03
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.03	0.09	0.43	0.03	0.03	0.03
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	9.79	3.16	4.99	0.27	0.33	0.31	3.63	1.17	1.85	0.10	0.12	0.11	0.43	0.14	0.22	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	5,754	2,136	8	0.12	0.88	1.94	0.06	0.14	0.13	0.13	0.94	2.05	0.07	0.15	0.14	0.02	0.12	0.27	0.01	0.02	0.02
2	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	12,303	4,272	8	0.12	0.97	1.00	0.06	0.17	0.16	0.34	2.75	2.81	0.17	0.49	0.46	0.05	0.37	0.38	0.02	0.06	0.06

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	12.56	21.61	54.16	5.25	8.66	8.10
Total Annual 2020 (tpy)	1.08	1.95	4.64	0.38	0.64	0.60

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:

Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M7G. Unmitigated Construction Worker Commute Emissions
Alternative 2 - Full Dam Removal

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	45	47	Oregon
Copco 1	56	78	California
Copco 2	40	69	California
Iron Gate	80	83	California
1	2	3	4

Road Conditions	Average
ADT	Average

Dam	Peak Daily Emissions, lbs/day (2020)													
	ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	1.50	30.67	1.18	0.03	2.48	0.01	0.02	0.04	2.41	0.39	0.01	0.01	0.02	0.36
Copco 1	0.60	12.50	1.31	0.01	3.12	0.06	0.02	0.04	3.00	0.53	0.06	0.01	0.02	0.45
Copco 2	0.75	15.56	1.63	0.02	2.30	0.08	0.03	0.05	2.14	0.42	0.07	0.01	0.02	0.32
Iron Gate	0.53	11.11	1.16	0.01	4.39	0.05	0.02	0.03	4.29	0.71	0.05	0.01	0.01	0.64
Total	3.38	69.85	5.28	0.07	12.29	0.20	0.10	0.15	11.84	2.06	0.19	0.02	0.07	1.78
California %	56%	56%	78%	62%	80%	94%	76%	76%	80%	81%	94%	76%	76%	80%
Oregon %	44%	44%	22%	38%	20%	6%	24%	24%	20%	19%	6%	24%	24%	20%

Dam	Annual Emissions, tons/year (2020)													
	ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	0.04	0.72	0.03	0.00	0.06	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.01
Copco 1	0.02	0.49	0.05	0.00	0.12	0.00	0.00	0.00	0.12	0.02	0.00	0.00	0.00	0.02
Copco 2	0.03	0.54	0.06	0.00	0.08	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00	0.01
Iron Gate	0.02	0.46	0.05	0.00	0.18	0.00	0.00	0.00	0.18	0.03	0.00	0.00	0.00	0.03
Total	0.11	2.21	0.18	0.00	0.44	0.01	0.00	0.01	0.43	0.07	0.01	0.00	0.00	0.06
California %	67%	67%	85%	72%	87%	96%	83%	84%	87%	87%	96%	83%	84%	87%
Oregon %	33%	33%	15%	28%	13%	4%	17%	16%	13%	13%	4%	17%	16%	13%

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M7H. Daily Unmitigated Haul Truck Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Road Conditions	Average
ADT	Average

		Peak Daily	Round Trip	Daily Emissions (lbs/day) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	160	1	0.09	0.17	0.59	0.00	0.31	0.01	0.01	0.00	0.29	0.06	0.01	0.00	0.00	0.04
(Oregon)	Concrete	50	3	0.09	0.16	0.56	0.00	0.29	0.01	0.01	0.00	0.27	0.05	0.01	0.00	0.00	0.04
	Metal	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	Building Waste	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	J.C. Boyle Subtotal	230	92	0.70	1.23	4.42	0.03	2.30	0.08	0.07	0.03	2.13	0.42	0.07	0.02	0.01	0.32
Copco 1	Concrete	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
(California)	Metal	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Building Waste	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Copco 1 Subtotal	60	126	0.899	3.966	10.782	0.029	1.736	0.348	0.057	0.045	1.286	0.547	0.320	0.014	0.019	0.193
Copco 2	Earth	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
(California)	Concrete (dam)	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
	Concrete (plant)	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (dam)	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Metal (plant)	10	56	0.70	3.08	8.39	0.02	1.35	0.27	0.04	0.03	1.00	0.43	0.25	0.01	0.01	0.15
	Building Waste	10	56	0.70	3.08	8.39	0.02	1.35	0.27	0.04	0.03	1.00	0.43	0.25	0.01	0.01	0.15
	Wood-stave planks	2	240	0.60	2.64	7.19	0.02	1.16	0.23	0.04	0.03	0.86	0.36	0.21	0.01	0.01	0.13
	Copco 2 Subtotal	127	418	2.63	11.62	31.60	0.08	5.09	1.02	0.17	0.13	3.77	1.60	0.94	0.04	0.06	0.57
Iron Gate	Earth	800	2	2.00	8.81	23.96	0.06	3.86	0.77	0.13	0.10	2.86	1.21	0.71	0.03	0.04	0.43
(California)	Concrete	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
	Metal	5	54	0.34	1.49	4.04	0.01	0.65	0.13	0.02	0.02	0.48	0.20	0.12	0.01	0.01	0.07
	Building Waste	5	54	0.34	1.49	4.04	0.01	0.65	0.13	0.02	0.02	0.48	0.20	0.12	0.01	0.01	0.07
	Iron Gate Subtotal	860	112	2.80	12.34	33.54	0.09	5.40	1.08	0.18	0.14	4.00	1.70	1.00	0.04	0.06	0.60
	Grand Total	**1,277**	**748**	**7.03**	**29.16**	**80.35**	**0.24**	**14.53**	**2.53**	**0.47**	**0.35**	**11.18**	**4.27**	**2.33**	**0.12**	**0.15**	**1.68**
	California Total	1047	656	6.33	27.93	75.92	0.20	12.22	2.45	0.40	0.32	9.05	3.85	2.25	0.10	0.14	1.36
	Oregon Total	230	92	0.70	1.23	4.42	0.03	2.30	0.08	0.07	0.03	2.13	0.42	0.07	0.02	0.01	0.32
	California %	82%	88%	90%	96%	94%	86%	84%	97%	85%	91%	81%	90%	97%	85%	91%	81%
	Oregon %	18%	12%	10%	4%	6%	14%	16%	3%	15%	9%	19%	10%	3%	15%	9%	19%

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M7I. Annual Unmitigated Haul Truck Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Road Conditions	Average
ADT	Average

		Annual	Round Trip	Annual Emissions (tons per year) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	8,500	1	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Concrete	2,600	3	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Metal	430	44	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Building Waste	200	44	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	11,730	92	0.01	0.02	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.01
Copco 1 (California)	Concrete	4,000	2	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Metal	170	62	0.01	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	30	62	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	4,200	126	0.01	0.06	0.15	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Copco 2 (California)	Earth	90	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Concrete (dam)	400	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Concrete (plant)	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (dam)	45	62	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal (plant)	145	56	0.01	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	60	56	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood-stave planks	45	240	0.01	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	785	418	0.02	0.07	0.20	0.00	0.03	0.01	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00
Iron Gate (California)	Earth	60,000	2	0.07	0.33	0.90	0.00	0.14	0.03	0.00	0.00	0.11	0.05	0.03	0.00	0.00	0.02
	Concrete	750	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	130	54	0.00	0.02	0.05	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	40	54	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	60,920	112	0.08	0.36	0.98	0.00	0.16	0.03	0.01	0.00	0.12	0.05	0.03	0.00	0.00	0.02
	Grand Total	**77,635**	**748**	**0.12**	**0.51**	**1.41**	**0.00**	**0.26**	**0.04**	**0.01**	**0.01**	**0.20**	**0.08**	**0.04**	**0.00**	**0.00**	**0.03**
	California Total	65,905	656	0.11	0.49	1.33	0.00	0.21	0.04	0.01	0.01	0.16	0.07	0.04	0.00	0.00	0.02
	Oregon Total	11,730	92	0.01	0.02	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.01
	California %	85%	88%	90%	96%	94%	85%	83%	97%	85%	90%	80%	90%	97%	85%	90%	80%
	Oregon %	15%	12%	10%	4%	6%	15%	17%	3%	15%	10%	20%	10%	3%	15%	10%	20%

Key:

ADT = average daily traffic
CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

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Table M7J. Unmitigated Fugitive Dust Emissions
Alternative 2 - Full Dam Removal

	Unmitigated Peak Daily Emissions, lbs/day								Max	
	PM_{10}				$PM_{2.5}$					
Phase	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	156.08	2.06	1.41	79.14	32.60	0.43	0.29	16.53	236.63	49.42
Building Demolition	0.91	0.68	1.35	4.52	0.19	0.14	0.28	0.94	6.78	1.41
Drilling and Blasting	n/a	158.32	n/a	n/a	n/a	158.32	n/a	n/a	0.00	0.00
Total	156.99	161.06	2.77	83.66	32.79	158.89	0.58	17.47	243.42	50.83

Note:
Copco 1 dam removal activities occur before remaining three dams; therefore, Copco 1 is not included in the maximum daily emissions.

	Unmitigated Annual Emissions (tons/year) - 2020								Grand Total	
	PM_{10}				$PM_{2.5}$					
Phase	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	7.73	0.08	0.05	1.86	1.61	0.02	0.01	0.39	9.71	2.03
Building Demolition	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00
Drilling and Blasting	n/a	7.03	n/a	n/a	n/a	7.03	n/a	n/a	7.03	7.03
Total	7.73	7.11	0.05	1.87	1.61	7.04	0.01	0.39	16.76	9.06

Key:
lbs/day = pounds per day
PM2.5 = fine particulate matter
PM10 = inhalable particulate matter

Table M7K. URBEMIS Model Inputs for Iron Gate
Alternative 2 - Full Dam Removal

Iron Gate

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading			
Phase Start Date	June 1, 2020			
Phase End Date	September 23, 2020			
Work Days/Week	5			
			Mitigation	
Cut/Fill	1,320,000	cy	1,320,000	cy
Truck Capacity	22	cy	22	cy
Total Truck Trips	60,000		60,000	
Duration	83	days	99	days
Daily Trips	723	trips/day	606	trips/day
Amount of onsite cut/fill	15,904	cubic yards/day	13,333	cubic yards/day

Note: Phase end date modified to calculate correct daily cut/fill rate.

Area	571,900	sq. ft.
	13.13	acres

BUILDING DEMOLITION

Building Waste	10,800	cf	
Start Date	June 1, 2020		
End Date	June 7, 2020		
Work Days/Week	5		
Width	23.2	ft	
Length	23.2	ft	
Height	20.0	ft	(estimated)
Volume	10,800	ft3	

Daily Volume to be Demolished Concurrently

Width	10.4	ft
Length	10.4	ft
Height	20.0	ft
Volume	2,160	ft3

Table M7L. URBEMIS Model Inputs for Copco 1
Alternative 2 - Full Dam Removal

Copco 1

BUILDING DEMOLITION

Building Waste	8,100	cf	
	Dam Removal	Demo	
Start Date	December 30, 2019	December 30, 2019	
End Date	April 15, 2020	January 3, 2020	
Work Days/Week	5		
Total Volume to be Removed			
Width	20.1	ft	
Length	20.1	ft	
Height	20.0	ft	(estimated)
Volume	8,100	ft3	
Daily Volume to be Demolished Concurrently			
Width	9.0	ft	
Length	9.0	ft	
Height	20.0	ft	
Volume	1,620	ft3	

Removal assumed to occur during equipment mobilization to allow construction equipment to access the site.

Area	100,085	sq. ft.
	2.30	acres

Table M7M. URBEMIS Model Inputs for Copco 2
Alternative 2 - Full Dam Removal

Copco 2

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading	
Work Days/Week	5	
Phase Start Date	April 24, 2020	
Phase End Date	July 29, 2020	
Cut/Fill	1,800	cy
Truck Capacity	22	cy
Total Truck Trips	82	
Duration	69	days
Daily Trips	1	trips/day
Amount of onsite cut/fill	26.09	cubic yards/day

BUILDING DEMOLITION

Building Waste	16,200	cf	
	Demo		
Start Date	April 24, 2020		
End Date	April 28, 2020		
Work Days/Week	5		
Total Volume to be Removed			
Width	28.5	ft	
Length	28.5	ft	
Height	20.0	ft	(estimated)
Volume	16,200	ft3	
Daily Volume to be Demolished Concurrently			
Width	12.7	ft	
Length	12.7	ft	
Height	20.0	ft	
Volume	3,240	ft3	
Area	120,590	sq. ft.	
	2.77	acres	

Table M7N. URBEMIS Inputs for JC Boyle
Alternative 2 - Full Dam Removal

J.C. Boyle

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading	
Phase Start Date	May 29, 2020	
Phase End Date	August 3, 2020	
Work Days/Week	5	
Cut/Fill	168,000	cy
Truck Capacity	22	cy
Total Truck Trips	7,636	
Duration	47	days
Daily Trips	162	trips/day
Amount of onsite cut/fill	3,574.47	cubic yards/day

Cut/fill volume includes quantities for cofferdam (2,000 cy) and soil cover (13,000 cy)

Area	423,140	sq. ft.
	9.71	acres

BUILDING DEMOLITION

Building Waste	54,000		
Start Date	May 29, 2020		
End Date	June 5, 2020		
Work Days/Week	5		
Width	52.0	ft	
Length	52.0	ft	
Height	20.0	ft	(estimated)
Volume	54,000	ft3	

Daily Volume to be Demolished Concurrently

Width	23.2	ft
Length	23.2	ft
Height	20.0	ft
Volume	10,800	ft3

Table M7O. Daily Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 2 - Full Facilities Removal (Proposed Action)

						Emissions (lbs/day)					
				One-way	Trips	Loaded		Empty		Total	
Dam	**Waste Material**	**Disposal Site**	**Haul Route**	**Distance (mi)**	**Daily**	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
J.C. Boyle (Oregon)	Earth	Right abutment site	Existing unpaved haul road	0.5	160	5	1	4	0	9	1
	Concrete	D/S scour hole	Existing unpaved canal road	1.5	50	5	1	4	0	9	1
				2	210	10	1	7	1	18	2
									Water control	5	1
Copco 1 (California)	Concrete	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
									Water control	2	0
Copco 2 (California)	Earth	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
	Concrete (dam)	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
				2	100	7	1	5	0	12	1
									Water control	4	0
Iron Gate (California)	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	800	54	5	38	4	93	9
	Concrete	Left abutment site	Existing unpaved access roads	1	50	3	0	2	0	6	1
				2	850	58	6	41	4	99	10
									Water control	31	3

Dust Control Measures

Water Exposed Surfaces
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency *3x daily*
Notes: "Trips" are one-way.

Table M7P. Annual Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 2 - Full Facilities Removal (Proposed Action)

Dam	Waste Material	Disposal Site	Haul Route	One-way Distance (mi)	Trips Total	Emissions (tons/year) - 2020: Loaded PM_{10}	Loaded $PM_{2.5}$	Empty PM_{10}	Empty $PM_{2.5}$	Total PM_{10}	Total $PM_{2.5}$
J.C. Boyle (Oregon)	Earth	Right abutment site	Existing unpaved haul road	0.5	8,500	0.14	0.01	0.10	0.01	0.24	0.02
	Concrete	D/S scour hole	Existing unpaved canal road	1.5	2,600	0.13	0.01	0.09	0.01	0.22	0.02
				2	11,100	0	0	0	0	0	0
									Water control	0	0
Copco 1 (California)	Concrete	Right abutment site	Improve unpaved access road	1	4,000	0.13	0.01	0.09	0.01	0.23	0.02
									Water control	0	0
Copco 2 (California)	Earth	Right abutment site	Improve unpaved access road	1	90	0.00	0.00	0.00	0.00	0.01	0.00
	Concrete (dam)	Right abutment site	Improve unpaved access road	1	400	0.01	0.00	0.01	0.00	0.02	0.00
				2	490	0	0	0	0	0	0
									Water control	0	0
Iron Gate (California)	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	60,000	2.01	0.20	1.41	0.14	3.42	0.34
	Concrete	Left abutment site	Existing unpaved access roads	1	750	0.03	0.00	0.02	0.00	0.04	0.00
				2	60,750	2	0	1	0	3	0
									Water control	1	0

Dust Control Measures

<u>Water Exposed Surfaces</u>
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency *3x daily*
Notes: "Trips" are one-way.

Table M7Q. Emission Factors for Unpaved Road Dust

Criteria Pollutants

Unpaved Road Dust Emission Factor

$$E = k(s/12)^a (W/3)^b$$

Vehicles traveling on unpaved surfaces at industrial sites

where:

k, a, and b = empirical constants
E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)

Typical silt content values

Haul road = 0.1 % (Lowest silt content from Emission Factor documentation)

Emission Factor Documentation for AP-42, Section 13.2.2: Unpaved Roads (September 1998)

Truck Weight (CAT 740 articulated truck)

Empty = 36.5 ton
Loaded = 80.0 ton

Constants for Equation

Constant	Industrial Roads	
	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.15	1.5
a	0.9	0.9
b	0.45	0.45

Natural Mitigation Emission Factor

$$E_{ext} = E[(365 - P)/365]$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT
E = unpaved road dust emission factor
P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

P = 88.3 days (Klamath Falls SSW) http://www.ocs.orst.edu/county_climate/Klamath_files/Klamath.html#table2a
= 84 days (Siskiyou County) http://www.foreclosuredeals.com/list/ca/siskiyou/foreclosure-auctions/

Unmitigated Emission Factors (lb/VMT)

Type	Haul Roads	
	PM_{10}	$PM_{2.5}$
Empty	0.1	0.01
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Klamath County

Type	Haul Roads	
	PM_{10}	$PM_{2.5}$
Empty	0.0	0.00
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Siskiyou County

Type	Haul Roads	
	PM_{10}	$PM_{2.5}$
Empty	0.0	0.00
Loaded	0.1	0.01

Table M8A. Summary of Daily Unmitigated Off-Road Construction Emissions (Alternative 3)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	63	248	313	2	12	11
Copco 1	26	159	117	1	6	5
Copco 2	19	56	80	1	4	3
J.C. Boyle	12	19	49	5	8	7
Total	120	483	560	9	30	27
California %	90%	96%	91%	43%	73%	73%
Oregon %	10%	4%	9%	57%	27%	27%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M8B. Summary of Annual Unmitigated Off-Road Construction Emissions (Alternative 3)

	Alternative 3 Unmitigated 2020 Annual Emissions - Construction Equipment (tpy)					
	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	2.6	10.3	13.0	0.1	0.5	0.5
Copco 1	1.0	6.2	4.6	0.0	0.2	0.2
Copco 2	1.0	2.4	3.7	0.1	0.2	0.2
J.C. Boyle	0.9	1.2	3.1	0.3	0.4	0.4
Total	5.5	20.1	24.4	0.4	1.3	1.2
California %	84%	94%	87%	40%	69%	69%
Oregon %	16%	6%	13%	60%	31%	31%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M8C. Unmitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 3)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	**Equipment Description**	**OFFROAD Category**	**Rating (hp)**	**Fuel Type**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.02	3.60	6.59	0.02	0.24	0.22	0.04	0.15	0.27	0.00	0.01	0.01
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.67	4.94	4.22	0.01	0.23	0.21	0.03	0.21	0.18	0.00	0.01	0.01
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX120	Excavators	646	Diesel	0.12	0.46	0.61	0.00	0.02	0.02	9.60	36.68	49.01	0.19	1.77	1.63	0.40	1.52	2.03	0.01	0.07	0.07
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	36.27	132.59	182.31	0.65	6.66	6.13	1.51	5.50	7.57	0.03	0.28	0.25
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.21	0.84	1.53	0.00	0.06	0.06	4.45	18.05	32.69	0.05	1.31	1.20	0.18	0.75	1.36	0.00	0.05	0.05
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.20	4.38	0.54	0.01	0.07	0.05	0.01	0.18	0.02	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.09	0.72	1.69	0.00	0.08	0.06	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.11	0.87	2.06	0.00	0.10	0.08	0.00	0.04	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.17	10.55	6.39	0.02	0.33	0.30	0.05	0.44	0.27	0.00	0.01	0.01
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.14	1.52	0.89	0.00	0.04	0.04	2.93	32.78	19.12	0.07	0.92	0.90	0.12	1.36	0.79	0.00	0.04	0.04

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	63.33	248.42	313.49	1.56	12.32	11.37
Total Annual 2020 (tpy)	2.63	10.31	13.01	0.06	0.51	0.47

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M8D. Unmitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 3)

Maximum Daily Work Hours 8

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Quantity						2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Primary	Secondary	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.17	4.11	7.54	0.02	0.28	0.25	0.05	0.16	0.29	0.00	0.01	0.01
1	1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.03	0.22	0.19	0.00	0.01	0.01
1	0	Excavator - hydraulic ram	Excavators	321	Diesel	0.11	0.42	0.55	0.00	0.02	0.02	0.62	2.36	3.10	0.01	0.11	0.10	0.02	0.09	0.12	0.00	0.00	0.00
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	Excavators	219.5	Diesel	0.15	0.59	0.82	0.00	0.03	0.03	1.16	4.60	6.31	0.03	0.22	0.20	0.05	0.18	0.25	0.00	0.01	0.01
3	0	Excavator - <20,000 lb	Excavators	168	Diesel	0.18	1.72	1.00	0.00	0.05	0.05	1.62	15.28	8.91	0.03	0.45	0.41	0.06	0.60	0.35	0.00	0.02	0.02
1	0	Loader - WA250 IT	Rubber Tired Loaders	138	Diesel	0.20	1.61	1.22	0.00	0.07	0.06	0.48	3.92	2.96	0.01	0.16	0.15	0.02	0.15	0.12	0.00	0.01	0.01
1	0	Loader - WA450	Rubber Tired Loaders	273	Diesel	0.12	0.45	0.73	0.00	0.03	0.02	0.57	2.19	3.50	0.01	0.13	0.12	0.02	0.09	0.14	0.00	0.00	0.00
2	0	Dump truck - articulated, 30 ton, Cat 730	Off-Highway Trucks	325	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	1.55	5.66	7.78	0.03	0.28	0.26	0.06	0.22	0.30	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.71	15.18	1.89	0.02	0.23	0.16	0.03	0.59	0.07	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.32	2.49	5.86	0.01	0.29	0.22	0.01	0.10	0.23	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.39	3.03	7.14	0.02	0.35	0.27	0.02	0.12	0.28	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	1.06	22.67	2.82	0.03	0.35	0.24	0.04	0.88	0.11	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.34	12.05	7.30	0.02	0.37	0.34	0.05	0.47	0.28	0.00	0.01	0.01
1	1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	Other Construction Equipment	106	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	2.83	28.69	21.67	0.05	1.12	1.10	0.11	1.12	0.85	0.00	0.04	0.04
4	4	Drills - air/hydraulic track, jackleg, or sinker	Bore/Drill Rigs	291	Diesel	0.07	0.50	0.24	0.00	0.01	0.01	2.91	20.51	9.75	0.11	0.27	0.25	0.11	0.80	0.38	0.00	0.01	0.01
2	2	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	53	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	0.71	7.17	5.42	0.01	0.28	0.27	0.03	0.28	0.21	0.00	0.01	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	25.97	159.30	116.91	1.05	5.85	5.27
Total Annual 2020 (tpy)	1.01	6.21	4.56	0.04	0.23	0.21

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M8E. Unmitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 3)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	9,989	904	8	0.10	0.35	0.64	0.00	0.02	0.02	0.58	2.06	3.77	0.01	0.14	0.13	0.03	0.12	0.21	0.00	0.01	0.01
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.05	0.34	0.29	0.00	0.02	0.01
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	16,200	1,200	8	0.11	0.42	0.55	0.00	0.02	0.02	1.23	4.71	6.20	0.02	0.23	0.21	0.05	0.18	0.23	0.00	0.01	0.01
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	24,372	1,808	8	0.11	0.42	0.55	0.00	0.02	0.02	1.23	4.71	6.20	0.02	0.23	0.21	0.07	0.27	0.35	0.00	0.01	0.01
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	0.15	0.57	1.02	0.00	0.04	0.03	1.33	4.97	8.86	0.03	0.30	0.28	0.09	0.34	0.61	0.00	0.02	0.02
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	0.12	0.45	0.73	0.00	0.03	0.02	0.99	3.81	6.08	0.02	0.22	0.20	0.01	0.03	0.05	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	7,702	928	8	0.14	0.49	0.68	0.00	0.02	0.02	1.98	7.23	9.94	0.04	0.36	0.33	0.06	0.21	0.29	0.00	0.01	0.01
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	0.22	0.72	1.57	0.00	0.06	0.05	0.90	3.02	6.57	0.01	0.24	0.22	0.03	0.10	0.21	0.00	0.01	0.01
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	2.34	18.31	43.09	0.10	2.11	1.61	0.16	1.24	2.92	0.01	0.14	0.11	0.01	0.08	0.20	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	2.34	18.31	43.09	0.10	2.11	1.61	0.10	0.76	1.78	0.00	0.09	0.07	0.01	0.05	0.12	0.00	0.01	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	0.22	1.95	1.18	0.00	0.06	0.06	0.67	6.03	3.65	0.01	0.19	0.17	0.00	0.01	0.01	0.00	0.00	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	1.14	3.03	14.06	0.93	1.00	0.97	0.78	2.08	9.67	0.64	0.69	0.67	0.05	0.14	0.66	0.04	0.05	0.05
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.50	0.16	0.25	0.01	0.02	0.02
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,572	728	8	0.19	1.92	1.45	0.00	0.08	0.07	0.20	2.03	1.53	0.00	0.08	0.08	0.01	0.09	0.07	0.00	0.00	0.00
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	4,193	1,456	8	0.19	1.92	1.45	0.00	0.08	0.07	0.53	5.41	4.09	0.01	0.21	0.21	0.02	0.25	0.19	0.00	0.01	0.01

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	18.71	56.05	79.77	1.03	3.62	3.36
Total Annual 2020 (tpy)	0.98	2.36	3.73	0.07	0.18	0.17

Legend:

Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M8F. Unmitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 3)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Hours	VOC	CO	NOx	SOx	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	17,680	1,600	8	0.07	0.21	0.79	0.04	0.06	0.06	0.43	1.23	4.64	0.24	0.37	0.35	0.04	0.12	0.46	0.02	0.04	0.04
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	3,256	800	8	0.07	0.14	0.48	0.04	0.07	0.06	0.32	0.62	2.19	0.18	0.31	0.29	0.01	0.02	0.05	0.00	0.01	0.01
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000	Diesel	Diesel Excavators	321	9,612	712	8	0.09	0.22	0.59	0.05	0.09	0.08	0.49	1.26	3.33	0.30	0.50	0.47	0.02	0.06	0.15	0.01	0.02	0.02
2	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	51,332	3,808	8	0.09	0.22	0.59	0.05	0.09	0.08	0.98	2.53	6.65	0.59	0.99	0.93	0.12	0.30	0.79	0.07	0.12	0.11
1	Hydraulic excavator, 6 cy	Diesel	Diesel Excavators	513	11,014	488	8	0.09	0.22	0.59	0.05	0.09	0.08	0.78	2.02	5.32	0.47	0.79	0.75	0.02	0.06	0.16	0.01	0.02	0.02
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	11,912	1,504	8	0.09	0.18	0.56	0.05	0.09	0.08	0.79	1.55	4.84	0.45	0.76	0.71	0.04	0.07	0.23	0.02	0.04	0.03
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,300	1,000	8	0.08	0.12	0.31	0.05	0.08	0.07	3.04	4.22	11.32	1.81	2.83	2.65	0.04	0.05	0.14	0.02	0.04	0.03
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	9,280	1,000	8	0.09	0.12	0.40	0.05	0.08	0.08	0.36	0.51	1.67	0.21	0.34	0.31	0.02	0.03	0.10	0.01	0.02	0.02
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.03	0.02	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	12,582	2,104	8	0.08	0.09	0.19	0.05	0.07	0.07	0.25	0.27	0.60	0.15	0.23	0.22	0.03	0.04	0.08	0.02	0.03	0.03
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.03	0.09	0.43	0.03	0.03	0.03
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	9.79	3.16	4.99	0.27	0.33	0.31	3.63	1.17	1.85	0.10	0.12	0.11	0.43	0.14	0.22	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	2,888	1,072	8	0.12	0.88	1.94	0.06	0.14	0.13	0.13	0.94	2.05	0.07	0.15	0.14	0.01	0.06	0.14	0.00	0.01	0.01
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	3,087	1,072	8	0.12	0.97	1.00	0.06	0.17	0.16	0.17	1.37	1.41	0.09	0.24	0.23	0.01	0.09	0.09	0.01	0.02	0.02

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	11.90	18.97	49.43	4.87	7.92	7.41
Total Annual 2020 (tpy)	0.86	1.20	3.09	0.25	0.41	0.38

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:

Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M8G. Unmitigated Construction Worker Commute Emissions

Alternative 3 - Partial Dam Removal

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	41	47	Oregon
Copco 1	56	78	California
Copco 2	38	69	California
Iron Gate	80	83	California
1	2	3	4

Road Conditions	Average
ADT	Average

	Peak Daily Emissions, lbs/day (2020)													
Dam	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Road Dust**
J.C. Boyle	1.37	27.94	1.07	0.02	2.26	0.01	0.02	0.03	2.20	0.36	0.01	0.01	0.01	0.33
Copco 1	0.55	11.39	1.19	0.01	3.11	0.06	0.02	0.03	3.00	0.52	0.05	0.01	0.01	0.45
Copco 2	0.75	15.56	1.63	0.02	2.19	0.08	0.03	0.05	2.04	0.40	0.07	0.01	0.02	0.31
Iron Gate	0.51	10.56	1.10	0.01	4.39	0.05	0.02	0.03	4.29	0.71	0.05	0.01	0.01	0.64
Total	3.17	65.45	5.00	0.06	11.95	0.19	0.09	0.15	11.52	1.99	0.18	0.02	0.06	1.73
California %	57%	57%	79%	63%	81%	95%	77%	77%	81%	82%	95%	77%	77%	81%
Oregon %	43%	43%	21%	37%	19%	5%	23%	23%	19%	18%	5%	23%	23%	19%

	Annual Emissions, tons/year (2020)													
Dam	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Road Dust**
J.C. Boyle	0.03	0.66	0.03	0.00	0.05	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.01
Copco 1	0.02	0.44	0.05	0.00	0.12	0.00	0.00	0.00	0.12	0.02	0.00	0.00	0.00	0.02
Copco 2	0.03	0.54	0.06	0.00	0.08	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00	0.01
Iron Gate	0.02	0.44	0.05	0.00	0.18	0.00	0.00	0.00	0.18	0.03	0.00	0.00	0.00	0.03
Total	0.10	2.08	0.17	0.00	0.43	0.01	0.00	0.01	0.42	0.07	0.01	0.00	0.00	0.06
California %	68%	68%	85%	73%	88%	97%	84%	84%	88%	88%	97%	84%	84%	88%
Oregon %	32%	32%	15%	27%	12%	3%	16%	16%	12%	12%	3%	16%	16%	12%

Key:

ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M8H. Daily Unmitigated Haul Truck Emissions
Alternative 3 - Partial Facilities Removal

Road Conditions	Average
ADT	Average

		Peak Daily	**Round Trip**	**Daily Emissions (lbs/day) - 2020**													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Earth	160	1	0.09	0.17	0.59	0.00	0.31	0.01	0.01	0.00	0.29	0.06	0.01	0.00	0.00	0.04
(Oregon)	Concrete	50	3	0.09	0.16	0.56	0.00	0.29	0.01	0.01	0.00	0.27	0.05	0.01	0.00	0.00	0.04
	Metal	10	44	0.26	0.46	1.64	0.01	0.85	0.03	0.03	0.01	0.79	0.16	0.03	0.01	0.01	0.12
	J.C. Boyle Subtotal	220	48	0.44	0.78	2.79	0.02	1.45	0.05	0.04	0.02	1.34	0.27	0.05	0.01	0.01	0.20
Copco 1	Concrete	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
(California)	Metal	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Copco 1 Subtotal	55	64	0.51	2.26	6.14	0.02	0.99	0.20	0.03	0.03	0.73	0.31	0.18	0.01	0.01	0.11
Copco 2	Earth	0	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(California)	Concrete	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
	Metal	15	58	1.09	4.79	13.03	0.03	2.10	0.42	0.07	0.05	1.55	0.66	0.39	0.02	0.02	0.23
	Wood-stave planks	2	240	0.60	2.64	7.19	0.02	1.16	0.23	0.04	0.03	0.86	0.36	0.21	0.01	0.01	0.13
	Copco 2 Subtotal	67	302	1.81	7.99	21.71	0.06	3.50	0.70	0.12	0.09	2.59	1.10	0.64	0.03	0.04	0.39
Iron Gate	Earth	800	2	2.00	8.81	23.96	0.06	3.86	0.77	0.13	0.10	2.86	1.21	0.71	0.03	0.04	0.43
(California)	Concrete	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
	Metal	5	54	0.34	1.49	4.04	0.01	0.65	0.13	0.02	0.02	0.48	0.20	0.12	0.01	0.01	0.07
	Iron Gate Subtotal	855	58	2.46	10.85	29.50	0.08	4.75	0.95	0.16	0.12	3.52	1.50	0.88	0.04	0.05	0.53
	Grand Total	**1,197**	**472**	**5.22**	**21.87**	**60.14**	**0.17**	**10.69**	**1.90**	**0.35**	**0.26**	**8.18**	**3.17**	**1.75**	**0.09**	**0.11**	**1.23**
	California Total	977	424	4.78	21.10	57.35	0.15	9.23	1.85	0.30	0.24	6.84	2.91	1.70	0.08	0.10	1.03
	Oregon Total	220	48	0.44	0.78	2.79	0.02	1.45	0.05	0.04	0.02	1.34	0.27	0.05	0.01	0.01	0.20
	California %	82%	90%	92%	96%	95%	88%	86%	97%	87%	92%	84%	92%	97%	87%	92%	84%
	Oregon %	18%	10%	8%	4%	5%	12%	14%	3%	13%	8%	16%	8%	3%	13%	8%	16%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M8I. Annual Unmitigated Haul Truck Emissions
Alternative 3 - Partial Facilities Removal

Road Conditions	Average
ADT	Average

Dam	Waste Material	Annual Trips	Round Trip Distance (mi)	Annual Emissions (tons per year) - 2020													
				ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Paved Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Paved Road Dust
J.C. Boyle	Earth	8,500	1	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Concrete	1,300	3	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	255	44	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	10,055	48	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Copco 1	Concrete	3,710	2	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
(California)	Metal	65	62	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	3,775	64	0.01	0.03	0.09	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Copco 2	Earth	0	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(California)	Concrete	150	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	50	58	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood-stave planks	45	240	0.01	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	245	302	0.01	0.04	0.10	0.00	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Iron Gate	Earth	60,000	2	0.07	0.33	0.90	0.00	0.14	0.03	0.00	0.00	0.11	0.05	0.03	0.00	0.00	0.02
(California)	Concrete	500	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	75	54	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	60,575	58	0.08	0.34	0.94	0.00	0.15	0.03	0.00	0.00	0.11	0.05	0.03	0.00	0.00	0.02
	Grand Total	**74,650**	**472**	**0.10**	**0.43**	**1.17**	**0.00**	**0.20**	**0.04**	**0.01**	**0.01**	**0.16**	**0.06**	**0.03**	**0.00**	**0.00**	**0.02**
	California Total	64,595	424	0.09	0.41	1.13	0.00	0.18	0.04	0.01	0.00	0.13	0.06	0.03	0.00	0.00	0.02
	Oregon Total	10,055	48	0.01	0.01	0.04	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	California %	87%	90%	93%	97%	96%	90%	89%	98%	90%	94%	86%	93%	98%	90%	94%	86%
	Oregon %	13%	10%	7%	3%	4%	10%	11%	2%	10%	6%	14%	7%	2%	10%	6%	14%

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Note:
Annual trips estimated from ratio of the quantity of waste disposed during Alternative 3 as compared to Alternative 2.

Key:
ADT = average daily traffic
CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

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Table M8J. Unmitigated Fugitive Dust Emissions
Alternative 3 - Partial Dam Removal

	Peak Daily Emissions, lbs/day									
	PM_{10}				$PM_{2.5}$				Max	
Phase	Iron Gate	Copco 1	Copco 2	JC Boyle	Iron Gate	Copco 1	Copco 2	JC Boyle	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	155.73	0.46	0.79	77.10	32.52	0.10	0.17	16.10	233.63	48.79
Building Demolition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Drilling and Blasting	n/a	158.32	n/a	n/a	n/a	158.32	n/a	n/a	0.00	0.00
Total	155.73	158.78	0.79	77.10	32.52	158.41	0.17	16.10	233.63	48.79

Note:
Copco 1 dam removal activities occur before remaining three dams; therefore, Copco 1 is not included in the maximum daily emissions.

	Annual Emissions (tons/year) - 2020									
	PM_{10}				$PM_{2.5}$				Grand Total	
Phase	Iron Gate	Copco 1	Copco 2	JC Boyle	Iron Gate	Copco 1	Copco 2	JC Boyle	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	7.71	0.02	0.03	1.81	1.61	0.00	0.01	0.38	9.57	2.00
Building Demolition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Drilling and Blasting	n/a	7.03	n/a	n/a	n/a	7.03	n/a	n/a	7.03	7.03
Total	7.71	7.05	0.03	1.81	1.61	7.03	0.01	0.38	16.59	9.03

Key:
lbs/day = pounds per day
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter

Table M8K. URBEMIS Model Inputs for Iron Gate
Alternative 3 - Partial Dam Removal

Iron Gate

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

			Mitigation	
Construction Phase	Fine Site Grading			
Phase Start Date	June 1, 2020			
Phase End Date	September 23, 2020			
Work Days/Week	5			
Cut/Fill	1,320,000	cy	1,320,000	cy
Truck Capacity	22	cy	22	cy
Total Truck Trips	60,000		60,000	
Duration	83	days	99	days
Daily Trips	723	trips/day	606	trips/day
Amount of onsite cut/fill	15,904	cubic yards/day	13,333	cubic yards/day

Note: Phase end date modified to calculate correct daily cut/fill rate.

Area	509,600	sq. ft.
	11.70	acres

BUILDING DEMOLITION

Buildings will not be removed at Iron Gate

Table M8L. URBEMIS Model Inputs for Copco 1
Alternative 3 - Partial Dam Removal

<u>Copco 1</u>

FUGITIVE DUST

Area	44,680	sq. ft.
	1.03	acres

Table M8M. URBEMIS Model Inputs for Copco 2
Alternative 3 - Partial Dam Removal

Copco 2

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading	
Work Days/Week	5	

Construct Left Side Cofferdam

Phase Start Date	April 24, 2020	
Phase End Date	July 29, 2020	
Cut/Fill	1,800	cy
Truck Capacity	22	cy
Total Truck Trips	82	
Duration	69	days
Daily Trips	1	trips/day
Amount of onsite cut/fill	26.09	cubic yards/day
Area	24,890	sq. ft.
	0.57	acres

BUILDING DEMOLITION

Buildings will not be removed at Copco 2

Table M8N. URBEMIS Inputs for JC Boyle
Alternative 3 - Partial Dam Removal

J.C. Boyle

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading	
Phase Start Date	May 29, 2020	
Phase End Date	August 3, 2020	
Work Days/Week	5	
Cut/Fill	168,000	cy
Truck Capacity	22	cy
Total Truck Trips	7,636	
Duration	47	days
Daily Trips	162	trips/day
Amount of onsite cut/fill	3,574.47	cubic yards/day

Cut/fill volume includes quantities for cofferdam (2,000 cy) and soil cover (13,000 cy)

Area	223,930	sq. ft.
	5.14	acres

BUILDING DEMOLITION

Buildings will not be demolished

Table M8O. Daily Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 3 - Partial Facilities Removal

Dam	Waste Material	Disposal Site	Haul Route	One-way Distance (mi)	Trips Daily	Emissions (lbs/day) Loaded PM_{10}	Loaded $PM_{2.5}$	Empty PM_{10}	Empty $PM_{2.5}$	Total PM_{10}	Total $PM_{2.5}$
J.C. Boyle (Oregon)	Earth	Right abutment site	Existing unpaved haul road	0.5	160	5	1	4	0	9	1
	Concrete	D/S scour hole	Existing unpaved canal road	1.5	50	5	1	4	0	9	1
				2	210	10	1	7	1	18	2
									Water control	5	1
Copco 1 (California)	Concrete	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
									Water control	2	0
Copco 2 (California)	Earth	Right abutment site	Improve unpaved access road	1	0	0	0	0	0	0	0
	Concrete (dam)	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
				2	50	3	0	2	0	6	1
									Water control	2	0
Iron Gate (California)	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	800	54	5	38	4	93	9
	Concrete	Left abutment site	Existing unpaved access roads	1	50	3	0	2	0	6	1
				2	850	58	6	41	4	99	10
									Water control	31	3

Dust Control Measures

<u>Water Exposed Surfaces</u>
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency *3x daily*
Notes: "Trips" are one-way.

Table M8P. Annual Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 3 - Partial Facilities Removal

Dam	Waste Material	Disposal Site	Haul Route	One-way Distance (mi)	Trips Total	Emissions (tons/year) - 2020 Loaded PM_{10}	Loaded $PM_{2.5}$	Empty PM_{10}	Empty $PM_{2.5}$	Total PM_{10}	Total $PM_{2.5}$
J.C. Boyle	Earth	Right abutment site	Existing unpaved haul road	0.5	8,500	0	0	0	0	0	0.0
(Oregon)	Concrete	D/S scour hole	Existing unpaved canal road	1.5	1,300	0	0	0	0	0	0.0
				2	9,800	0	0.0	0	0.0	0	0.0
									Water control	0	0
Copco 1	Concrete	Right abutment site	Improve unpaved access road	1	3,710	0	0	0	0	0	0.0
									Water control	0	0
(California)											
Copco 2	Earth	Right abutment site	Improve unpaved access road	1	0	0	0	0	0	0	0.0
(California)	Concrete (dam)	Right abutment site	Improve unpaved access road	1	150	0	0	0	0	0	0.0
				2	150	0.0	0.00	0.0	0.00	0.0	0.00
									Water control	0	0
Iron Gate	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	60,000	2	0	1	0	3	0.3
(California)	Concrete	Left abutment site	Existing unpaved access roads	1	500	0	0	0	0	0	0.0
				2	60,500	2	0	1	0	3	0
									Water control	1	0

Dust Control Measures

<u>Water Exposed Surfaces</u>
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency *3x daily*
Notes: "Trips" are one-way.

Table M8Q. Emission Factors for Unpaved Road Dust

Criteria Pollutants

Unpaved Road Dust Emission Factor

$$E = k(s/12)^a (W/3)^b$$

Vehicles traveling on unpaved surfaces at industrial sites

where:

k, a, and b = empirical constants
E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)

Typical silt content values

Haul road = 0.1 % (Lowest silt content from Emission Factor documentation)

Emission Factor Documentation for AP-42, Section 13.2.2: Unpaved Roads (September 1998)

Truck Weight (CAT 740 articulated truck)

Empty = 36.5 ton
Loaded = 80.0 ton

Constants for Equation

	Industrial Roads	
Constant	**$PM_{2.5}$**	**PM_{10}**
k (lb/VMT)	0.15	1.5
a	0.9	0.9
b	0.45	0.45

Natural Mitigation Emission Factor

$$E_{ext} = E[(365 - P)/365]$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT
E = unpaved road dust emission factor
P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

P = 88.3 days (Klamath Falls SSW) http://www.ocs.orst.edu/county_climate/Klamath_files/Klamath.html#table2a
= 84 days (Siskiyou County) http://www.foreclosuredeals.com/list/ca/siskiyou/foreclosure-auctions/

Unmitigated Emission Factors (lb/VMT)

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.1	0.01
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Klamath County

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.0	0.00
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Siskiyou County

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.0	0.00
Loaded	0.1	0.01

Table M9A. Summary of Daily Unmitigated Off-Road Construction Emissions (Alternative 4)

Location	Year	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	2023	10	54	52	0	2	2
Copco 1	2025	9	51	37	0	2	1
Copco 2	2024	9	51	42	0	2	2
J.C. Boyle	2022	8	14	45	3	6	5
Maximum		10	54	52	3	6	5

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M9B. Summary of Annual Unmitigated Off-Road Construction Emissions (Alternative 4)

		Alternative 4 Unmitigated Annual Emissions - Construction Equipment (tpy)					
Location	Year	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	2023	0.8	4.2	4.2	0.0	0.2	0.2
Copco 1	2025	0.6	3.2	2.6	0.0	0.1	0.1
Copco 2	2024	0.1	0.8	0.6	0.0	0.0	0.0
J.C. Boyle	2022	0.3	0.5	1.4	0.1	0.2	0.2
Maximum		0.8	4.2	4.2	0.1	0.2	0.2

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

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Table M9C. Unmitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 4)

Maximum Daily Work Hours 8 hours

							Peak Daily	2023 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2023 Emissions (tons per year)					
Quantity	**Equipment Description**	**OFFROAD Category**	**Rating (hp)**	**Fuel Type**	**Fuel Amount (gal)**	**Total Hours**	**Hours**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	23,409	2,280	8	0.09	0.33	0.45	0.00	0.02	0.02	0.50	1.93	2.69	0.01	0.10	0.09	0.07	0.28	0.38	0.00	0.01	0.01
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Cranes	130	Diesel	13,936	3,424	8	0.14	1.23	0.75	0.00	0.04	0.04	0.62	5.64	3.44	0.01	0.18	0.17	0.07	0.60	0.37	0.00	0.02	0.02
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	7,668	568	8	0.09	0.41	0.36	0.00	0.01	0.01	0.53	2.32	2.06	0.01	0.07	0.07	0.02	0.08	0.07	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	23,078	1,712	8	0.09	0.41	0.36	0.00	0.01	0.01	0.53	2.32	2.06	0.01	0.07	0.07	0.06	0.25	0.22	0.00	0.01	0.01
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	13,559	1,712	8	0.13	0.56	0.71	0.00	0.02	0.02	0.57	2.42	3.06	0.01	0.11	0.10	0.06	0.26	0.33	0.00	0.01	0.01
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	18,990	2,288	8	0.12	0.49	0.46	0.00	0.02	0.02	1.71	7.10	6.67	0.04	0.24	0.22	0.12	0.51	0.48	0.00	0.02	0.02
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	5,271	568	8	0.18	0.68	1.17	0.00	0.04	0.04	0.77	2.85	4.93	0.01	0.18	0.16	0.03	0.10	0.17	0.00	0.01	0.01
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	191	Gasoline	8,276	2,280	8	2.02	45.35	5.56	0.09	0.91	0.64	0.13	2.90	0.36	0.01	0.06	0.04	0.02	0.41	0.05	0.00	0.01	0.01
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,378	2,280	8	2.28	17.90	43.33	0.10	2.08	1.58	0.08	0.61	1.47	0.00	0.07	0.05	0.01	0.09	0.21	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	5,335	2,280	8	2.28	17.90	43.33	0.10	2.08	1.58	0.09	0.74	1.79	0.00	0.09	0.07	0.01	0.11	0.25	0.00	0.01	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	6,841	1,144	8	0.18	1.95	0.79	0.00	0.04	0.04	0.55	6.02	2.45	0.01	0.12	0.11	0.04	0.43	0.18	0.00	0.01	0.01
5	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	36,975	4,560	8	0.08	0.42	0.36	0.00	0.01	0.01	1.63	8.68	7.53	0.05	0.26	0.24	0.09	0.49	0.43	0.00	0.01	0.01
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	1,335	568	8	0.16	1.58	0.98	0.00	0.05	0.05	0.39	3.85	2.40	0.01	0.13	0.12	0.01	0.14	0.09	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	1,439	2,056	8	1.14	3.03	14.06	0.93	1.00	0.97	0.26	0.69	3.22	0.21	0.23	0.22	0.03	0.09	0.41	0.03	0.03	0.03
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	576	4,112	8	9.79	3.16	4.99	0.27	0.33	0.32	0.95	0.31	0.48	0.03	0.03	0.03	0.12	0.04	0.06	0.00	0.00	0.00
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,227	568	8	0.11	1.52	0.59	0.00	0.03	0.03	0.12	1.61	0.62	0.00	0.03	0.03	0.00	0.06	0.02	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	1,636	568	8	0.11	1.52	0.59	0.00	0.03	0.03	0.16	2.14	0.83	0.00	0.04	0.04	0.01	0.08	0.03	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	14,415	1,144	8	2.31	10.55	26.15	0.10	1.13	0.84	0.51	2.34	5.81	0.02	0.25	0.19	0.04	0.17	0.42	0.00	0.02	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	10.11	54.48	51.85	0.45	2.25	2.01
Total Annual 2023 (tpy)	0.82	4.17	4.17	0.05	0.19	0.17

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:

Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M9D. Unmitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 4)

Maximum Daily Work Hours 8 hours

							Peak Daily	2025 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2025 Emissions (tons per year)					
Quantity	**Equipment Description**	**OFFROAD Category**	**Rating (hp)**	**Fuel Type**	**Fuel Amount (gal)**	**Total Hours**	**Hours**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	20,951	1,896	8	0.08	0.32	0.36	0.00	0.01	0.01	0.46	1.89	2.13	0.01	0.08	0.07	0.05	0.22	0.25	0.00	0.01	0.01
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Cranes	130	Diesel	11,591	2,848	8	0.12	1.23	0.60	0.00	0.03	0.03	0.55	5.63	2.73	0.01	0.14	0.13	0.05	0.50	0.24	0.00	0.01	0.01
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)		321	Diesel	6,372	472																			
		Excavators					8	0.09	0.41	0.28	0.00	0.01	0.01	0.49	2.31	1.59	0.01	0.05	0.05	0.01	0.07	0.05	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	19,196	1,424	8	0.09	0.41	0.28	0.00	0.01	0.01	0.49	2.31	1.59	0.01	0.05	0.05	0.04	0.21	0.14	0.00	0.00	0.00
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	11,278	1,424	8	0.12	0.55	0.55	0.00	0.02	0.02	0.52	2.39	2.39	0.01	0.08	0.08	0.05	0.21	0.21	0.00	0.01	0.01
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	7,902	952	8	0.11	0.48	0.35	0.00	0.01	0.01	1.57	7.06	5.14	0.04	0.18	0.17	0.05	0.21	0.15	0.00	0.01	0.00
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,380	472	8	0.17	0.66	0.96	0.00	0.03	0.03	0.70	2.79	4.04	0.01	0.15	0.13	0.02	0.08	0.12	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	191	Gasoline	6,882	1,896	8	1.66	39.46	4.66	0.09	0.91	0.64	0.11	2.53	0.30	0.01	0.06	0.04	0.01	0.30	0.04	0.00	0.01	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	3,640	1,896	8	2.15	17.66	43.39	0.10	1.99	1.50	0.07	0.60	1.47	0.00	0.07	0.05	0.01	0.07	0.17	0.00	0.01	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	4,437	1,896	8	2.15	17.66	43.39	0.10	1.99	1.50	0.09	0.73	1.79	0.00	0.08	0.06	0.01	0.09	0.21	0.00	0.01	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	5,693	952	8	0.16	1.95	0.62	0.00	0.03	0.03	0.50	6.02	1.90	0.01	0.09	0.08	0.03	0.36	0.11	0.00	0.01	0.00
5	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	43,151	5,320	8	0.07	0.42	0.27	0.00	0.01	0.01	1.49	8.65	5.70	0.05	0.19	0.17	0.10	0.58	0.38	0.00	0.01	0.01
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	1,109	472	8	0.14	1.58	0.78	0.00	0.04	0.04	0.35	3.84	1.91	0.01	0.10	0.09	0.01	0.11	0.06	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	1,193	1,704	8	1.14	3.03	14.06	0.93	1.00	0.97	0.26	0.69	3.22	0.21	0.23	0.22	0.03	0.07	0.34	0.02	0.02	0.02
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	477	3,408	8	9.79	3.16	4.99	0.27	0.33	0.32	0.95	0.31	0.48	0.03	0.03	0.03	0.10	0.03	0.05	0.00	0.00	0.00
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,020	472	8	0.10	1.52	0.45	0.00	0.02	0.02	0.11	1.61	0.47	0.00	0.02	0.02	0.00	0.05	0.01	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	1,359	472	8	0.10	1.52	0.45	0.00	0.02	0.02	0.14	2.14	0.63	0.00	0.03	0.03	0.00	0.06	0.02	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	11,995	952	8	2.05	9.58	22.68	0.10	0.99	0.71	0.46	2.13	5.04	0.02	0.22	0.16	0.03	0.13	0.30	0.00	0.01	0.01

	ROG	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
Total Daily (lb/day)	9.28	51.49	37.49	0.43	1.63	1.48
Total Annual 2025 (tpy)	0.61	3.22	2.57	0.04	0.12	0.11

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M9E. Unmitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 4)

Maximum Daily Work Hours 8 hours

							Peak Daily	2024 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2024 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	4,862	440	8	0.08	0.32	0.40	0.00	0.01	0.01	0.48	1.91	2.39	0.01	0.09	0.08	0.01	0.05	0.07	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	2,670	656	8	0.13	1.23	0.67	0.00	0.04	0.03	0.58	5.63	3.06	0.01	0.16	0.15	0.01	0.12	0.06	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	1,512	112	8	0.09	0.41	0.32	0.00	0.01	0.01	0.51	2.31	1.81	0.01	0.06	0.06	0.00	0.02	0.01	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	4,421	328	8	0.09	0.41	0.32	0.00	0.01	0.01	0.51	2.31	1.81	0.01	0.06	0.06	0.01	0.05	0.04	0.00	0.00	0.00
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	2,598	328	8	0.13	0.55	0.62	0.00	0.02	0.02	0.54	2.41	2.71	0.01	0.10	0.09	0.01	0.05	0.06	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	3,718	448	8	0.11	0.48	0.40	0.00	0.01	0.01	1.63	7.08	5.86	0.04	0.21	0.19	0.02	0.10	0.08	0.00	0.00	0.00
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	1,039	112	8	0.17	0.67	1.06	0.00	0.04	0.04	0.73	2.82	4.47	0.01	0.16	0.15	0.01	0.02	0.03	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	845	440	8	1.82	42.10	5.08	0.09	0.91	0.64	0.06	1.43	0.17	0.00	0.03	0.02	0.00	0.04	0.00	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	1,030	440	8	1.82	42.10	5.08	0.09	0.91	0.64	0.08	1.74	0.21	0.00	0.04	0.03	0.00	0.05	0.01	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	1,340	224	8	0.17	1.95	0.70	0.00	0.03	0.03	0.52	6.02	2.16	0.01	0.10	0.10	0.01	0.08	0.03	0.00	0.00	0.00
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	5,709	704	8	0.08	0.42	0.32	0.00	0.01	0.01	1.24	6.93	5.24	0.04	0.18	0.16	0.01	0.08	0.06	0.00	0.00	0.00
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	263	112	8	0.15	1.58	0.88	0.00	0.05	0.04	0.37	3.84	2.14	0.01	0.11	0.10	0.00	0.03	0.01	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	280	400	8	1.14	3.03	14.06	0.93	1.00	0.97	0.26	0.69	3.22	0.21	0.23	0.22	0.01	0.02	0.08	0.01	0.01	0.01
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	112	800	8	9.79	3.16	4.99	0.27	0.33	0.32	0.95	0.31	0.48	0.03	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	242	112	8	0.11	1.52	0.51	0.00	0.02	0.02	0.11	1.61	0.54	0.00	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	323	112	8	0.11	1.52	0.51	0.00	0.02	0.02	0.15	2.14	0.72	0.00	0.03	0.03	0.00	0.01	0.01	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	2,822	224	8	2.16	10.00	24.18	0.10	1.05	0.77	0.48	2.22	5.37	0.02	0.23	0.17	0.01	0.03	0.08	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	9.21	51.40	42.36	0.44	1.85	1.66
Total Annual 2024 (tpy)	0.14	0.76	0.64	0.01	0.03	0.03

Key:

CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:

Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M9F. Unmitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 4)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2022 Emission Factors (g/hp-hr or g/gal for on-highway sources) VOC	CO	NOx	SOx	PM10	PM2.5	Peak Daily Emissions (lbs/day) VOC	CO	NOx	SO2	PM10	PM2.5	2022 Emissions (tons per year) VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	10,696	968	8	0.07	0.16	0.60	0.04	0.06	0.06	0.40	0.97	3.57	0.23	0.36	0.34	0.02	0.06	0.22	0.01	0.02	0.02
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	5,926	1,456	8	0.06	0.09	0.32	0.04	0.06	0.06	0.30	0.41	1.49	0.17	0.28	0.26	0.01	0.02	0.07	0.01	0.01	0.01
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000	Diesel	Diesel Excavators	321	3,240	240	8	0.08	0.15	0.41	0.05	0.08	0.08	0.48	0.86	2.30	0.29	0.46	0.43	0.01	0.01	0.03	0.00	0.01	0.01
1	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	9,813	728	8	0.08	0.15	0.41	0.05	0.08	0.08	0.48	0.86	2.30	0.29	0.46	0.43	0.02	0.04	0.10	0.01	0.02	0.02
1	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	5,766	728	8	0.09	0.12	0.38	0.05	0.08	0.08	0.37	0.53	1.66	0.22	0.35	0.33	0.02	0.02	0.08	0.01	0.02	0.01
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,101	976	8	0.08	0.09	0.22	0.05	0.08	0.07	1.21	1.38	3.17	0.72	1.10	1.03	0.04	0.04	0.10	0.02	0.03	0.03
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	2,227	240	8	0.08	0.09	0.26	0.05	0.08	0.07	0.35	0.40	1.09	0.21	0.32	0.30	0.01	0.01	0.02	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	1,859	968	8	3.13	7.29	3.89	0.10	0.59	0.35	0.11	0.25	0.13	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	2,265	968	8	3.13	7.29	3.89	0.10	0.59	0.35	0.13	0.30	0.16	0.00	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	2,918	488	8	0.08	0.08	0.17	0.05	0.07	0.07	0.25	0.26	0.52	0.15	0.23	0.21	0.01	0.01	0.02	0.00	0.01	0.01
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Diesel	Diesel Cement & Mortar Mixers	235	12,455	1,536	8	0.11	0.27	1.13	0.04	0.08	0.07	1.74	4.45	18.67	0.69	1.30	1.22	0.04	0.11	0.45	0.02	0.03	0.03
1	Compactor, Cat, vibratory, self propelled, 84"	Diesel	Diesel Rollers	138	564	240	8	0.09	0.16	0.41	0.05	0.09	0.08	0.21	0.40	0.99	0.12	0.22	0.20	0.00	0.01	0.01	0.00	0.00	0.00
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	610	872	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.01	0.04	0.18	0.01	0.01	0.01
2	Portable generator 1 KW	Gasoline	N/A - AP42 3.3-2	2.75	244	1,744	8	9.79	3.16	4.99	0.27	0.33	0.31	0.95	0.31	0.48	0.03	0.03	0.03	0.05	0.02	0.03	0.00	0.00	0.00
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	647	240	8	0.11	0.67	1.87	0.06	0.12	0.11	0.11	0.71	1.97	0.06	0.13	0.12	0.00	0.01	0.03	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	691	240	8	0.10	0.73	0.73	0.06	0.14	0.13	0.15	1.03	1.03	0.08	0.20	0.19	0.00	0.02	0.02	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	Diesel	N/A - MOBILE	450	6,149	488	8	2.00	3.07	10.18	0.10	0.49	0.26	0.44	0.68	2.26	0.02	0.11	0.06	0.01	0.02	0.07	0.00	0.00	0.00

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	7.94	14.48	45.03	3.50	5.82	5.39
Total Annual 2022 (tpy)	0.28	0.46	1.42	0.11	0.18	0.17

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M9G. Unmitigated Construction Worker Commute Emissions
Alternative 4 - Fish Passage at Four Dams

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	20	179	Oregon
Copco 1	25	270	California
Copco 2	20	101	California
Iron Gate	30	344	California
1	2	3	4

Road Conditior	Average
ADT	Average

Dam	Year	Peak Daily Emissions, lbs/day													
		ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	2022	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	1.07	0.16	0.00	0.00	0.00	0.16
Copco 1	2025	0.53	3.80	0.41	0.01	1.40	0.03	0.01	0.02	1.34	0.24	0.03	0.00	0.01	0.20
Copco 2	2024	0.47	3.38	0.37	0.01	1.12	0.03	0.01	0.02	1.07	0.19	0.02	0.00	0.01	0.16
Iron Gate	2023	0.77	5.69	0.62	0.01	1.69	0.04	0.02	0.02	1.61	0.29	0.04	0.00	0.01	0.24
Maximum		0.77	5.69	0.62	0.01	1.69	0.04	0.02	0.02	1.61	0.29	0.04	0.00	0.01	0.24

Dam	Year	Annual Emissions, tons/year													
		ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	2022	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.10	0.01	0.00	0.00	0.00	0.01
Copco 1	2025	0.07	0.51	0.06	0.00	0.19	0.00	0.00	0.00	0.18	0.03	0.00	0.00	0.00	0.03
Copco 2	2024	0.02	0.17	0.02	0.00	0.06	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.01
Iron Gate	2023	0.13	0.98	0.11	0.00	0.29	0.01	0.00	0.00	0.28	0.05	0.01	0.00	0.00	0.04
Total		0.23	1.66	0.18	0.00	0.63	0.01	0.01	0.01	0.61	0.11	0.01	0.00	0.00	0.09

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M9H. Daily Unmitigated Haul Truck Emissions
Alternative 4 - Fish Passage at Four Dams

Road Conditions	Average
ADT	Average

		Peak Daily	Round Trip	Daily Emissions (lbs/day)													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Concrete	9	148	0.76	1.16	3.85	0.04	2.56	0.07	0.08	0.04	2.38	0.46	0.07	0.02	0.02	0.36
(Oregon)	Rebar	1	121	0.07	0.11	0.35	0.00	0.23	0.01	0.01	0.00	0.22	0.04	0.01	0.00	0.00	0.03
2022	Wood	1	121	0.07	0.11	0.35	0.00	0.23	0.01	0.01	0.00	0.22	0.04	0.01	0.00	0.00	0.03
	J.C. Boyle Subtotal	11	390	0.89	1.37	4.55	0.05	3.03	0.08	0.09	0.04	2.81	0.54	0.08	0.02	0.02	0.42
Copco 1	Concrete	9	59	0.45	2.11	4.99	0.02	1.17	0.14	0.04	0.03	0.95	0.30	0.13	0.01	0.01	0.14
(California)	Rebar	1	120	0.10	0.48	1.13	0.00	0.26	0.03	0.01	0.01	0.21	0.07	0.03	0.00	0.00	0.03
2025	Wood	1	120	0.10	0.48	1.13	0.00	0.26	0.03	0.01	0.01	0.21	0.07	0.03	0.00	0.00	0.03
	Copco 1 Subtotal	11	299	0.66	3.06	7.24	0.03	1.69	0.21	0.06	0.05	1.38	0.43	0.19	0.02	0.02	0.21
Copco 2	Concrete	9	59	0.48	2.20	5.32	0.02	1.18	0.16	0.04	0.03	0.95	0.31	0.14	0.01	0.01	0.14
(California)	Rebar	1	120	0.11	0.50	1.20	0.00	0.27	0.04	0.01	0.01	0.21	0.07	0.03	0.00	0.00	0.03
2024	Wood	1	120	0.11	0.50	1.20	0.00	0.27	0.04	0.01	0.01	0.21	0.07	0.03	0.00	0.00	0.03
	Copco 2 Subtotal	11	299	0.69	3.19	7.72	0.03	1.71	0.23	0.06	0.05	1.38	0.45	0.21	0.02	0.02	0.21
Iron Gate	Concrete	9	50	0.43	1.97	4.88	0.02	1.01	0.15	0.04	0.03	0.80	0.28	0.14	0.01	0.01	0.12
(California)	Rebar	1	90	0.09	0.39	0.98	0.00	0.20	0.03	0.01	0.01	0.16	0.06	0.03	0.00	0.00	0.02
2023	Wood	1	90	0.09	0.39	0.98	0.00	0.20	0.03	0.01	0.01	0.16	0.06	0.03	0.00	0.00	0.02
	Iron Gate Subtotal	11	230	0.60	2.76	6.83	0.03	1.42	0.21	0.05	0.04	1.13	0.39	0.19	0.01	0.02	0.17
	Maximum	**11**	**390**	**0.89**	**3.19**	**7.72**	**0.05**	**3.03**	**0.23**	**0.09**	**0.05**	**2.81**	**0.54**	**0.21**	**0.02**	**0.02**	**0.42**

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M9I. Annual Unmitigated Haul Truck Emissions
Alternative 4 - Fish Passage at Four Dams

Road Conditions	Average
ADT	Average

Dam	Waste Material	Annual Trips	Round Trip Distance (mi)	Annual Emissions (tons per year)													
				ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Paved Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Paved Road Dust
J.C. Boyle 2022	Concrete	488	148	0.02	0.03	0.10	0.00	0.07	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.01
	Rebar	8	121	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	4	121	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	500	390	0.02	0.03	0.11	0.00	0.07	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00	0.01
Copco 1 (California) 2025	Concrete	725	59	0.02	0.08	0.20	0.00	0.05	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.01
	Rebar	13	120	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	6	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	744	299	0.02	0.09	0.21	0.00	0.05	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.01
Copco 2 (California) 2024	Concrete	250	59	0.01	0.03	0.07	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Rebar	4	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	3	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	257	299	0.01	0.03	0.08	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Iron Gate (California) 2023	Concrete	900	50	0.02	0.10	0.24	0.00	0.05	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.01
	Rebar	16	90	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	9	90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	925	230	0.02	0.10	0.26	0.00	0.05	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.01
	Maximum	**925**	**390**	**0.02**	**0.10**	**0.26**	**0.00**	**0.07**	**0.01**	**0.00**	**0.00**	**0.07**	**0.01**	**0.01**	**0.00**	**0.00**	**0.01**

Key:
ADT = average daily traffic
CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

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Table M9J. Unmitigated Fugitive Dust Emissions
Alternative 4 - Fish Passage at Four Dams

	Peak Daily Emissions, lbs/day								Maximum	
	PM_{10}				$PM_{2.5}$					
Year-->	2023	2025	2024	2022	2023	2025	2024	2022		
Phase	Iron Gate	Copco 1	Copco 2	JC Boyle	Iron Gate	Copco 1	Copco 2	JC Boyle	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	2.27	0.64	0.44	0.92	0.47	0.13	0.09	0.19	2.27	0.47
Building Demolition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Drilling and Blasting	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Total	2.27	0.64	0.44	0.92	0.47	0.13	0.09	0.19	2.27	0.47

	Annual Emissions (tons/year)								Maximum	
	PM_{10}				$PM_{2.5}$					
Year-->	2023	2025	2024	2022	2023	2025	2024	2022		
Phase	Iron Gate	Copco 1	Copco 2	JC Boyle	Iron Gate	Copco 1	Copco 2	JC Boyle	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	0.30	0.07	0.02	0.06	0.06	0.01	0.00	0.01	0.30	0.06
Building Demolition	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Drilling and Blasting	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00
Total	0.30	0.07	0.02	0.06	0.06	0.01	0.00	0.01	0.30	0.06

Table M9K. URBEMIS Model Inputs for Iron Gate
Alternative 4 - Fish Passage at Four Dams

<u>Iron Gate</u>

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	1/1/2023	
Phase End Date	12/31/2023	
Area	222,530	sq. ft.
	5.11	acres
Workdays	260	

BUILDING DEMOLITION

Buildings will not be removed at Iron Gate

Table M9L. URBEMIS Model Inputs for Copco 1
Alternative 4 - Fish Passage at Four Dams

<u>Copco 1</u>

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	2/1/2025	
Phase End Date	11/30/2025	
Area	63,780	sq. ft.
	1.46	acres
Workdays	215	

BUILDING DEMOLITION

No buildings will be demolished at Copco 1

Table M9M. URBEMIS Model Inputs for Copco 2
Alternative 4 - Fish Passage at Four Dams

Copco 2

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	6/1/2024	
Phase End Date	9/30/2024	
Area	43,490	sq. ft.
	1.00	acres

Note: Square feet adjusted to calculate acres correctly
(call with Scott Wright, 11/19/10)

Workdays	86

BUILDING DEMOLITION

Buildings will not be removed at Copco 2

Table M9N. URBEMIS Inputs for JC Boyle
Alternative 4 - Fish Passage at Four Dams

J.C. Boyle

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	5/1/2022	
Phase End Date	10/31/2022	
Area	90,810	sq. ft.
	2.08	acres
Workdays	131	

BUILDING DEMOLITION

No buildings will be demolished at JC Boyle

Table M10A. Summary of Daily Unmitigated Off-Road Construction Emissions (Alternative 5)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	63	248	313	2	12	11
Copco 1	26	159	117	1	6	5
Copco 2	11	52	70	0	3	3
J.C. Boyle	8	18	56	4	6	6
Total	109	478	557	7	27	25
California %	92%	96%	90%	46%	77%	77%
Oregon %	8%	4%	10%	54%	23%	23%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M10B. Summary of Annual Unmitigated Off-Road Construction Emissions (Alternative 5)

Location	VOC	CO	NOx	SO2	PM10	PM2.5
Iron Gate	2.6	10.3	13.0	0.1	0.5	0.5
Copco 1	1.0	6.2	4.6	0.0	0.2	0.2
Copco 2	0.2	0.7	1.1	0.0	0.0	0.0
J.C. Boyle	0.3	0.6	1.8	0.1	0.2	0.2
Total	4.1	17.8	20.4	0.2	1.0	0.9
California %	93%	97%	91%	50%	80%	80%
Oregon %	7%	3%	9%	50%	20%	20%

Key:
CO = carbon monoxide
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide
VOC = volatile organic compounds

Table M10C. Unmitigated Off-Road Construction Equipment Emissions for Iron Gate Dam (Alternative 5)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

					2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.02	3.60	6.59	0.02	0.24	0.22	0.04	0.15	0.27	0.00	0.01	0.01
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.67	4.94	4.22	0.01	0.23	0.21	0.03	0.21	0.18	0.00	0.01	0.01
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX120	Excavators	646	Diesel	0.12	0.46	0.61	0.00	0.02	0.02	9.60	36.68	49.01	0.19	1.77	1.63	0.40	1.52	2.03	0.01	0.07	0.07
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	36.27	132.59	182.31	0.65	6.66	6.13	1.51	5.50	7.57	0.03	0.28	0.25
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	0.21	0.84	1.53	0.00	0.06	0.06	4.45	18.05	32.69	0.05	1.31	1.20	0.18	0.75	1.36	0.00	0.05	0.05
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.20	4.38	0.54	0.01	0.07	0.05	0.01	0.18	0.02	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.09	0.72	1.69	0.00	0.08	0.06	0.00	0.03	0.07	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.11	0.87	2.06	0.00	0.10	0.08	0.00	0.04	0.09	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.17	10.55	6.39	0.02	0.33	0.30	0.05	0.44	0.27	0.00	0.01	0.01
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.46	1.22	5.64	0.37	0.40	0.39	0.02	0.05	0.23	0.02	0.02	0.02
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	6.35	2.05	3.23	0.17	0.21	0.21	0.26	0.08	0.13	0.01	0.01	0.01
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	0.14	1.52	0.89	0.00	0.04	0.04	2.93	32.78	19.12	0.07	0.92	0.90	0.12	1.36	0.79	0.00	0.04	0.04

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	63.33	248.42	313.49	1.56	12.32	11.37
Total Annual 2020 (tpy)	2.63	10.31	13.01	0.06	0.51	0.47

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M10D. Unmitigated Off-Road Construction Equipment Emissions for Copco 1 (Alternative 5)

Maximum Daily Work Hours	8
Dam Removal Duration	
Start Date	12/30/2019
End Date	4/15/2020
	78 (5 days/week)

Quantity						2020 Emission Factors (g/hp-hr or g/gal for on-highway						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Primary	Secondary	Equipment Description	OFFROAD Category	Rating (hp)	Fuel	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	0.10	0.35	0.64	0.00	0.02	0.02	1.17	4.11	7.54	0.02	0.28	0.25	0.05	0.16	0.29	0.00	0.01	0.01
1	1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.03	0.22	0.19	0.00	0.01	0.01
1	0	Excavator - hydraulic ram	Excavators	321	Diesel	0.11	0.42	0.55	0.00	0.02	0.02	0.62	2.36	3.10	0.01	0.11	0.10	0.02	0.09	0.12	0.00	0.00	0.00
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	Excavators	219.5	Diesel	0.15	0.59	0.82	0.00	0.03	0.03	1.16	4.60	6.31	0.03	0.22	0.20	0.05	0.18	0.25	0.00	0.01	0.01
3	0	Excavator - <20,000 lb	Excavators	168	Diesel	0.18	1.72	1.00	0.00	0.05	0.05	1.62	15.28	8.91	0.03	0.45	0.41	0.06	0.60	0.35	0.00	0.02	0.02
1	0	Loader - WA250 IT	Rubber Tired Loaders	138	Diesel	0.20	1.61	1.22	0.00	0.07	0.06	0.48	3.92	2.96	0.01	0.16	0.15	0.02	0.15	0.12	0.00	0.01	0.01
1	0	Loader - WA450	Rubber Tired Loaders	273	Diesel	0.12	0.45	0.73	0.00	0.03	0.02	0.57	2.19	3.50	0.01	0.13	0.12	0.02	0.09	0.14	0.00	0.00	0.00
2	0	Dump truck - articulated, 30 ton, Cat 730	Off-Highway Trucks	325	Diesel	0.14	0.49	0.68	0.00	0.02	0.02	1.55	5.66	7.78	0.03	0.28	0.26	0.06	0.22	0.30	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	0.71	15.18	1.89	0.02	0.23	0.16	0.03	0.59	0.07	0.00	0.01	0.01
1	1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.32	2.49	5.86	0.01	0.29	0.22	0.01	0.10	0.23	0.00	0.01	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad		Diesel	2.34	18.31	43.09	0.10	2.11	1.61	0.39	3.03	7.14	0.02	0.35	0.27	0.02	0.12	0.28	0.00	0.01	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4	N/A - Onroad		Gasoline	2.76	59.09	7.36	0.09	0.90	0.64	1.06	22.67	2.82	0.03	0.35	0.24	0.04	0.88	0.11	0.00	0.01	0.01
1	1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	0.22	1.95	1.18	0.00	0.06	0.06	1.34	12.05	7.30	0.02	0.37	0.34	0.05	0.47	0.28	0.00	0.01	0.01
1	1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	1.14	3.03	14.06	0.93	1.00	0.97	0.52	1.39	6.45	0.43	0.46	0.45	0.02	0.05	0.25	0.02	0.02	0.02
1	1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	9.79	3.16	4.99	0.27	0.33	0.32	7.25	2.34	3.70	0.20	0.24	0.24	0.28	0.09	0.14	0.01	0.01	0.01
4	4	Air compressor, 850-1200 cfm	Other Construction Equipment	106	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	2.83	28.69	21.67	0.05	1.12	1.10	0.11	1.12	0.85	0.00	0.04	0.04
4	4	Drills - air/hydraulic track, jackleg, or sinker	Bore/Drill Rigs	291	Diesel	0.07	0.50	0.24	0.00	0.01	0.01	2.91	20.51	9.75	0.11	0.27	0.25	0.11	0.80	0.38	0.00	0.01	0.01
2	2	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	53	Diesel	0.19	1.92	1.45	0.00	0.08	0.07	0.71	7.17	5.42	0.01	0.28	0.27	0.03	0.28	0.21	0.00	0.01	0.01

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	25.97	159.30	116.91	1.05	5.85	5.27
Total Annual 2020 (tpy)	1.01	6.21	4.56	0.04	0.23	0.21

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M10E. Unmitigated Off-Road Construction Equipment Emissions for Copco 2 (Alternative 5)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	ROG	CO	NOx	SOx	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5	ROG	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	4,862	440	8	0.10	0.35	0.64	0.00	0.02	0.02	0.58	2.06	3.77	0.01	0.14	0.13	0.02	0.06	0.10	0.00	0.00	0.00
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	2,670	656	8	0.17	1.23	1.05	0.00	0.06	0.05	0.77	5.65	4.82	0.01	0.26	0.24	0.02	0.12	0.10	0.00	0.01	0.00
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	1,512	112	8	0.11	0.42	0.55	0.00	0.02	0.02	0.62	2.36	3.10	0.01	0.11	0.10	0.00	0.02	0.02	0.00	0.00	0.00
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	4,421	328	8	0.11	0.42	0.55	0.00	0.02	0.02	0.62	2.36	3.10	0.01	0.11	0.10	0.01	0.05	0.06	0.00	0.00	0.00
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	2,598	328	8	0.15	0.57	1.02	0.00	0.04	0.03	0.67	2.49	4.43	0.01	0.15	0.14	0.01	0.05	0.09	0.00	0.00	0.00
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	3,718	448	8	0.14	0.49	0.68	0.00	0.02	0.02	1.98	7.23	9.94	0.04	0.36	0.33	0.03	0.10	0.14	0.00	0.01	0.00
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	1,039	112	8	0.22	0.72	1.57	0.00	0.06	0.05	0.90	3.02	6.57	0.01	0.24	0.22	0.01	0.02	0.05	0.00	0.00	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	845	440	8	2.34	18.31	43.09	0.10	2.11	1.61	0.08	0.62	1.46	0.00	0.07	0.05	0.00	0.02	0.04	0.00	0.00	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	1,030	440	8	2.34	18.31	43.09	0.10	2.11	1.61	0.10	0.76	1.78	0.00	0.09	0.07	0.00	0.02	0.05	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	1,340	224	8	0.22	1.95	1.18	0.00	0.06	0.06	0.67	6.03	3.65	0.01	0.19	0.17	0.01	0.08	0.05	0.00	0.00	0.00
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	5,709	704	8	0.09	0.42	0.55	0.00	0.02	0.02	1.52	7.03	9.12	0.04	0.32	0.29	0.02	0.08	0.10	0.00	0.00	0.00
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	263	112	8	0.20	1.58	1.38	0.00	0.07	0.07	0.49	3.85	3.35	0.01	0.18	0.16	0.00	0.03	0.02	0.00	0.00	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	280	400	8	1.14	3.03	14.06	0.93	1.00	0.97	0.26	0.69	3.22	0.21	0.23	0.22	0.01	0.02	0.08	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	242	112	8	0.19	1.92	1.45	0.00	0.08	0.07	0.20	2.03	1.53	0.00	0.08	0.07	0.00	0.01	0.01	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	323	112	8	0.19	1.92	1.45	0.00	0.08	0.07	0.27	2.71	2.04	0.01	0.11	0.10	0.00	0.02	0.01	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	2,822	224	8	3.00	13.26	36.04	0.10	1.50	1.18	0.67	2.95	8.01	0.02	0.33	0.26	0.01	0.04	0.11	0.00	0.00	0.00
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	112	800	8	9.79	3.16	4.99	0.27	0.33	0.30	0.95	0.31	0.48	0.03	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00

	ROG	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	11.33	52.12	70.38	0.44	3.01	2.71
Total Annual 2020 (tpy)	0.17	0.74	1.06	0.01	0.05	0.04

Key:
CO = carbon monoxide
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour
hp = horsepower
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SO2 = sulfur dioxide
tpy = tons per day

Legend:
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table M10F. Unmitigated Off-Road Construction Equipment Emissions for JC Boyle (Alternative 5)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway sources)						Peak Daily Emissions (lbs/day)						2020 Emissions (tons per year)					
Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Hours	VOC	CO	NOx	SOx	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5	VOC	CO	NOx	SO2	PM10	PM2.5
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	10,696	968	8	0.07	0.21	0.79	0.04	0.06	0.06	0.43	1.23	4.64	0.24	0.37	0.35	0.03	0.07	0.28	0.01	0.02	0.02
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	5,926	1,456	8	0.07	0.14	0.48	0.04	0.07	0.06	0.32	0.62	2.19	0.18	0.31	0.29	0.01	0.03	0.10	0.01	0.01	0.01
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000	Diesel	Diesel Excavators	321	3,240	240	8	0.09	0.22	0.59	0.05	0.09	0.08	0.49	1.26	3.33	0.30	0.50	0.47	0.01	0.02	0.05	0.00	0.01	0.01
1	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	9,813	728	8	0.09	0.22	0.59	0.05	0.09	0.08	0.49	1.26	3.33	0.30	0.50	0.47	0.02	0.06	0.15	0.01	0.02	0.02
1	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	5,766	728	8	0.09	0.18	0.56	0.05	0.09	0.08	0.39	0.77	2.42	0.22	0.38	0.36	0.02	0.04	0.11	0.01	0.02	0.02
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,101	976	8	0.08	0.12	0.31	0.05	0.08	0.07	1.22	1.69	4.53	0.72	1.13	1.06	0.04	0.05	0.14	0.02	0.03	0.03
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	2,227	240	8	0.09	0.12	0.40	0.05	0.08	0.08	0.36	0.51	1.67	0.21	0.34	0.31	0.01	0.01	0.03	0.00	0.01	0.00
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	1,859	968	8	3.60	7.91	4.61	0.10	0.64	0.39	0.12	0.27	0.16	0.00	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	2,265	968	8	3.60	7.91	4.61	0.10	0.64	0.39	0.15	0.33	0.19	0.00	0.03	0.02	0.01	0.02	0.01	0.00	0.00	0.00
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	2,918	488	8	0.08	0.09	0.19	0.05	0.07	0.07	0.25	0.27	0.60	0.15	0.23	0.22	0.01	0.01	0.02	0.00	0.01	0.01
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Diesel	Diesel Cement & Mortar Mixers	235	12,455	1,536	8	0.12	0.32	1.32	0.04	0.08	0.08	1.92	5.32	21.88	0.71	1.41	1.32	0.05	0.13	0.53	0.02	0.03	0.03
1	Compactor, Cat, vibratory, self propelled, 84"	Diesel	Diesel Rollers	138	564	240	8	0.09	0.26	0.62	0.05	0.11	0.10	0.23	0.64	1.50	0.13	0.27	0.25	0.00	0.01	0.02	0.00	0.00	0.00
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	610	872	8	1.14	3.03	14.06	0.93	1.00	0.94	0.26	0.69	3.22	0.21	0.23	0.21	0.01	0.04	0.18	0.01	0.01	0.01
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	647	240	8	0.12	0.88	1.94	0.06	0.14	0.13	0.13	0.94	2.05	0.07	0.15	0.14	0.00	0.01	0.03	0.00	0.00	0.00
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	691	240	8	0.12	0.97	1.00	0.06	0.17	0.16	0.17	1.37	1.41	0.09	0.24	0.23	0.00	0.02	0.02	0.00	0.00	0.00
1	Dump truck, on-highway 8x4, 18 cy	Diesel	N/A - MOBILE	450	6,149	488	8	2.06	3.65	13.08	0.10	0.53	0.30	0.46	0.81	2.91	0.02	0.12	0.07	0.01	0.02	0.09	0.00	0.00	0.00
2	Portable generator 1 KW	Gasoline	N/A - AP42 3.3-1	2.75	244	1,744	8	9.79	3.16	4.99	0.27	0.33	0.31	0.95	0.31	0.48	0.03	0.03	0.03	0.05	0.02	0.03	0.00	0.00	0.00

	VOC	CO	NOx	SO2	PM10	PM2.5
Total Daily (lb/day)	8.34	18.29	56.49	3.58	6.25	5.80
Total Annual 2020 (tpy)	0.29	0.57	1.78	0.12	0.20	0.18

Key:
CO = carbon monoxide
g/gal = grams per gallon
hp = horsepower
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
SO2 = sulfur dioxide

Legend:
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table M10G. Unmitigated Construction Worker Commute Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	17	47	Oregon
Copco 1	56	78	California
Copco 2	15	69	California
Iron Gate	80	83	California
1	2	3	4

Road Conditions	Average
ADT	Average

Dam	Peak Daily Emissions, lbs/day (2020)													
	ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	0.57	11.59	0.45	0.01	0.94	0.00	0.01	0.01	0.91	0.15	0.00	0.00	0.01	0.14
Copco 1	0.75	15.56	1.63	0.02	3.15	0.08	0.03	0.05	3.00	0.55	0.07	0.01	0.02	0.45
Copco 2	0.20	4.17	0.44	0.00	0.84	0.02	0.01	0.01	0.80	0.15	0.02	0.00	0.01	0.12
Iron Gate	1.07	22.23	2.32	0.02	4.50	0.11	0.04	0.07	4.29	0.78	0.10	0.01	0.03	0.64
Total	2.58	53.54	4.83	0.05	9.44	0.21	0.09	0.14	9.00	1.63	0.19	0.02	0.06	1.35
California %	78%	78%	91%	82%	90%	98%	90%	90%	90%	91%	98%	90%	90%	90%
Oregon %	22%	22%	9%	18%	10%	2%	10%	10%	10%	9%	2%	10%	10%	10%

Dam	Annual Emissions, tons/year (2020)													
	ROG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM10 Road Dust	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	PM2.5 Road Dust
J.C. Boyle	0.01	0.27	0.01	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Copco 1	0.03	0.61	0.06	0.00	0.12	0.00	0.00	0.00	0.12	0.02	0.00	0.00	0.00	0.02
Copco 2	0.01	0.14	0.02	0.00	0.03	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00
Iron Gate	0.04	0.92	0.10	0.00	0.19	0.00	0.00	0.00	0.18	0.03	0.00	0.00	0.00	0.03
Total	0.09	1.95	0.19	0.00	0.36	0.01	0.00	0.01	0.34	0.06	0.01	0.00	0.00	0.05
California %	86%	86%	94%	89%	94%	99%	94%	94%	94%	94%	99%	94%	94%	94%
Oregon %	14%	14%	6%	11%	6%	1%	6%	6%	6%	6%	1%	6%	6%	6%

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M10H. Daily Unmitigated Haul Truck Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Road Conditions	Average
ADT	Average

		Peak Daily	**Round Trip**	**Daily Emissions (lbs/day) - 2020**													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Concrete (In)	9	148	0.78	1.38	4.95	0.04	2.58	0.09	0.08	0.04	2.38	0.47	0.08	0.02	0.02	0.36
(Oregon)	Rebar	1	121	0.07	0.13	0.45	0.00	0.23	0.01	0.01	0.00	0.22	0.04	0.01	0.00	0.00	0.03
	Wood	1	121	0.07	0.13	0.45	0.00	0.23	0.01	0.01	0.00	0.22	0.04	0.01	0.00	0.00	0.03
	J.C. Boyle Subtotal	11	390	0.92	1.63	5.85	0.05	3.05	0.10	0.09	0.04	2.81	0.56	0.09	0.02	0.02	0.42
Copco 1	Concrete (Out)	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
(California)	Metal	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Building Waste	5	62	0.39	1.71	4.64	0.01	0.75	0.15	0.02	0.02	0.55	0.24	0.14	0.01	0.01	0.08
	Copco 1 Subtotal	60	126	0.90	3.97	10.78	0.03	1.74	0.35	0.06	0.04	1.29	0.55	0.32	0.01	0.02	0.19
Copco 2	Concrete (In)	9	59	0.66	2.92	7.95	0.02	1.28	0.26	0.04	0.03	0.95	0.40	0.24	0.01	0.01	0.14
(California)	Rebar	1	120	0.15	0.66	1.80	0.00	0.29	0.06	0.01	0.01	0.21	0.09	0.05	0.00	0.00	0.03
	Wood	1	120	0.15	0.66	1.80	0.00	0.29	0.06	0.01	0.01	0.21	0.09	0.05	0.00	0.00	0.03
	Copco 2 Subtotal	11	299	0.96	4.25	11.55	0.03	1.86	0.37	0.06	0.05	1.38	0.59	0.34	0.02	0.02	0.21
Iron Gate	Earth	800	2	2.00	8.81	23.96	0.06	3.86	0.77	0.13	0.10	2.86	1.21	0.71	0.03	0.04	0.43
(California)	Concrete (Out)	50	2	0.12	0.55	1.50	0.00	0.24	0.05	0.01	0.01	0.18	0.08	0.04	0.00	0.00	0.03
	Metal	5	54	0.34	1.49	4.04	0.01	0.65	0.13	0.02	0.02	0.48	0.20	0.12	0.01	0.01	0.07
	Building Waste	5	54														
	Iron Gate Subtotal	860	112	2.46	10.85	29.50	0.08	4.75	0.95	0.16	0.12	3.52	1.50	0.88	0.04	0.05	0.53
	Grand Total	**942**	**927**	**5.24**	**20.69**	**57.68**	**0.18**	**11.39**	**1.78**	**0.37**	**0.26**	**8.99**	**3.18**	**1.63**	**0.09**	**0.11**	**1.35**
	California Total	931	537	4.32	19.06	51.83	0.14	8.34	1.67	0.27	0.22	6.18	2.63	1.54	0.07	0.09	0.93
	Oregon Total	11	390	0.92	1.63	5.85	0.05	3.05	0.10	0.09	0.04	2.81	0.56	0.09	0.02	0.02	0.42
	California %	99%	58%	82%	92%	90%	75%	73%	94%	75%	83%	69%	82%	94%	75%	83%	69%
	Oregon %	1%	42%	18%	8%	10%	25%	27%	6%	25%	17%	31%	18%	6%	25%	17%	31%

Key:
ADT = average daily traffic
CO = carbon monoxide
lbs/day = pounds per day
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

Table M10I. Annual Unmitigated Haul Truck Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Road Conditions	Average
ADT	Average

		Annual	Round Trip	Annual Emissions (tons per year) - 2020													
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**ROG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM10 Paved Road Dust**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**PM2.5 Paved Road Dust**
J.C. Boyle	Concrete (In)	350	148	0.02	0.03	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.01
	Rebar	6	121	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	3	121	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	J.C. Boyle Subtotal	359	390	0.02	0.03	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.01
Copco 1 (California)	Concrete (Out)	4,000	2	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Metal	170	62	0.01	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	30	62	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 1 Subtotal	4,200	126	0.01	0.06	0.15	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Copco 2 (California)	Concrete (In)	125	59	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Rebar	2	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wood	2	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Copco 2 Subtotal	129	299	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Iron Gate (California)	Earth	60,000	2	0.07	0.33	0.90	0.00	0.14	0.03	0.00	0.00	0.11	0.05	0.03	0.00	0.00	0.02
	Concrete (Out)	750	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Metal	130	54	0.00	0.02	0.05	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Building Waste	40	54	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Iron Gate Subtotal	60,920	112	0.08	0.36	0.98	0.00	0.16	0.03	0.01	0.00	0.12	0.05	0.03	0.00	0.00	0.02
	Grand Total	**65,608**	**927**	**0.11**	**0.47**	**1.29**	**0.00**	**0.24**	**0.04**	**0.01**	**0.01**	**0.19**	**0.07**	**0.04**	**0.00**	**0.00**	**0.03**
	California Total	65,249	537	0.10	0.44	1.19	0.00	0.19	0.04	0.01	0.00	0.14	0.06	0.04	0.00	0.00	0.02
	Oregon Total	359	390	0.02	0.03	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.01
	California %	99%	58%	86%	94%	92%	81%	79%	96%	80%	87%	75%	87%	96%	80%	87%	75%
	Oregon %	1%	42%	14%	6%	8%	19%	21%	4%	20%	13%	25%	13%	4%	20%	13%	25%

Key:
ADT = average daily traffic
CO = carbon monoxide
mi = miles
NOx = nitrogen oxides
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter
ROG = reactive organic gases
SOx = sulfur oxides

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Table M10J. Unmitigated Fugitive Dust Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

	Peak Daily Emissions, lbs/day									
	PM_{10}				$PM_{2.5}$				Max	
Phase	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	156.08	1.03	0.44	0.92	32.60	0.21	0.09	0.19	157.45	32.88
Building Demolition	0.91	0.68	n/a	n/a	0.19	0.14	n/a	n/a	0.91	0.19
Drilling and Blasting	n/a	158.32	n/a	n/a	n/a	158.32	n/a	n/a	0.00	0.00
Total	156.99	160.03	0.44	0.92	32.79	158.67	0.09	0.19	158.36	33.07

	Annual Emissions (tons/year) - 2020									
	PM_{10}				$PM_{2.5}$				Grand Total	
Phase	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	**Iron Gate**	**Copco 1**	**Copco 2**	**JC Boyle**	PM_{10}	$PM_{2.5}$
Cut/Fill Activities	7.73	0.04	0.02	0.02	1.61	0.01	0.00	0.00	7.80	1.63
Building Demolition	0.00	0.00	n/a	n/a	0.00	0.00	n/a	n/a	0.00	0.00
Drilling and Blasting	n/a	7.03	n/a	n/a	n/a	7.03	n/a	n/a	7.03	7.03
Total	7.73	7.07	0.02	0.02	1.61	7.04	0.00	0.00	14.83	8.66

Key:
lbs/day = pounds per day
PM10 = inhalable particulate matter
PM2.5 = fine particulate matter

Table M10K. URBEMIS Model Inputs for Iron Gate

Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Iron Gate

WASTE (DISPOSED OFFSITE) - CUT/FILL VOLUMES

Construction Phase	Fine Site Grading			
Phase Start Date	June 1, 2020			
Phase End Date	September 23, 2020			
Work Days/Week	5			
			Mitigation	
Cut/Fill	1,320,000	cy	1,320,000	cy
Truck Capacity	20	cy	22	cy
Total Truck Trips	66,000		60,000	
Duration	83	days	99	days
Daily Trips	795	trips/day	606	trips/day
Amount of onsite cut/fill	15,904	cubic yards/day	13,333	cubic yards/day
Area	571,900	sq. ft.		
	13.13	acres		

BUILDING DEMOLITION

Building Waste	10,800	cf	
Start Date	June 1, 2020		
End Date	June 7, 2020		
Work Days/Week	5		
Width	23.2	ft	
Length	23.2	ft	
Height	20.0	ft	(estimated)
Volume	10,800	ft3	

Daily Volume to be Demolished Concurrently

Width	10.4	ft
Length	10.4	ft
Height	20.0	ft
Volume	2,160	ft3

Table M10L. URBEMIS Model Inputs for Copco 1
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

<u>Copco 1</u>

BUILDING DEMOLITION

Building Waste	8,100	cf	
	Dam Removal	Demo	
Start Date	December 30, 2019	December 30, 2019	
End Date	April 15, 2020	January 3, 2020	
Work Days/Week	5		
<u>Total Volume to be Removed</u>			
Width	20.1	ft	
Length	20.1	ft	
Height	20.0	ft	(estimated)
Volume	8,100	ft3	
<u>Daily Volume to be Demolished Concurrently</u>			
Width	9.0	ft	
Length	9.0	ft	
Height	20.0	ft	
Volume	1,620	ft3	
Area	100,085	sq. ft.	
	2.30	acres	

Table M10M. URBEMIS Model Inputs for Copco 2
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Copco 2

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	4/24/2020	
Phase End Date	7/29/2020	
Area	43,490	sq. ft.
	1.00	acres

BUILDING DEMOLITION

Buildings will not be removed at Copco 2

Table M10N. URBEMIS Inputs for JC Boyle
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

J.C. Boyle

CONSTRUCTION EQUIPMENT FUGITIVE DUST

Phase Start Date	5/29/2020	
Phase End Date	8/3/2020	
Area	90,810	sq. ft.
	2.08	acres

BUILDING DEMOLITION

Buildings will not be removed at JC Boyle

Table M10O. Daily Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

						Emissions (lbs/day)					
				One-way	***Trips***	***Loaded***		***Empty***		***Total***	
Dam	***Waste Material***	***Disposal Site***	***Haul Route***	***Distance (mi)***	***Daily***	***PM_{10}***	***$PM_{2.5}$***	***PM_{10}***	***$PM_{2.5}$***	***PM_{10}***	***$PM_{2.5}$***
Copco 1	Concrete	Right abutment site	Improve unpaved access road	1	50	3	0	2	0	6	1
									Water control	2	0
(California)											
Iron Gate	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	800	54	5	38	4	93	9
(California)	Concrete	Left abutment site	Existing unpaved access roads	1	50	3	0	2	0	6	1
				2	850	58	6	41	4	99	10
									Water control	31	3

Dust Control Measures

Water Exposed Surfaces
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency 3x daily
Notes: "Trips" are one-way.

Table M10P. Annual Unmitigated Fugitive Dust Emissions from Unpaved Roads
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

						Emissions (tons/year) - 2020					
				One-way	Trips	Loaded		Empty		Total	
Dam	Waste Material	Disposal Site	Haul Route	Distance (mi)	Total	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Copco 1	Concrete	Right abutment site	Improve unpaved access road	1	4,000	0	0	0	0	0	0.0
(California)									Water control	0	0
Iron Gate	Earth	Spillway and Left abutment borrow sites	Existing unpaved access roads	1	60,000	2	0	1	0	3	0.3
(California)	Concrete	Left abutment site	Existing unpaved access roads	1	750	0	0	0	0	0	0.0
				2	60,750	2	0	1	0	3	0
									Water control	1	0

Dust Control Measures

<u>Water Exposed Surfaces</u>
2x daily 55%
3x daily 69%

(values from URBEMIS)
Watering Frequency *3x daily*
Notes: "Trips" are one-way.

Table M10Q. Emission Factors for Unpaved Road Dust

Criteria Pollutants

Unpaved Road Dust Emission Factor

$$E = k(s/12)^a (W/3)^b$$

Vehicles traveling on unpaved surfaces at industrial sites

where:

k, a, and b = empirical constants
E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)

Typical silt content values

Haul road = 0.1 % (Lowest silt content from Emission Factor documentation)

Emission Factor Documentation for AP-42, Section 13.2.2: Unpaved Roads (September 1998)

Truck Weight (CAT 740 articulated truck)

Empty = 36.5 ton
Loaded = 80.0 ton

Constants for Equation

	Industrial Roads	
Constant	**$PM_{2.5}$**	**PM_{10}**
k (lb/VMT)	0.15	1.5
a	0.9	0.9
b	0.45	0.45

Natural Mitigation Emission Factor

$$E_{ext} = E[(365 - P)/365]$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT
E = unpaved road dust emission factor
P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

P = 88.3 days (Klamath Falls SSW) http://www.ocs.orst.edu/county_climate/Klamath_files/Klamath.html#table2a
= 84 days (Siskiyou County) http://www.foreclosuredeals.com/list/ca/siskiyou/foreclosure-auctions/

Unmitigated Emission Factors (lb/VMT)
Unpaved Roads

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.1	0.01
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Klamath County

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.0	0.00
Loaded	0.1	0.01

Natural Mitigated Emission Factors (lb/VMT) - Siskiyou County

	Haul Roads	
Type	**PM_{10}**	**$PM_{2.5}$**
Empty	0.0	0.00
Loaded	0.1	0.01

Table M11A. Summary of Drilling and Blasting Emissions

Copco 1 - Demolition

Daily Emissions (lbs/day)				
	Pollutant			
Source	**CO**	**NOx**	**PM10**	**PM2.5**
Blast Hole Drilling	--	--	146.9	146.9
Dust Entrainment from Blasting	--	--	11.4	11.4
Explosives Detonation	24.7	6.3	--	--
Total	24.7	6.3	158.3	158.3

Annual Emissions (tons/year)				
	Pollutant			
Source	**CO**	**NOx**	**PM10**	**PM2.5**
Blast Hole Drilling	--	--	6.5	6.5
Dust Entrainment from Blasting	--	--	0.5	0.5
Explosives Detonation	1.1	0.3	--	--
Total	1.1	0.3	7.0	7.0

Note:
Emissions of other pollutants are negligible and are not reported.

Table M11B. Blasting Emission Calculations

Emission Factors

Activity	Emission Factor Source
Blast Hole Drilling	MDAQMD
Blasting	MDAQMD
Explosives Detonation	MDAQMD

Source:
Mojave Desert Air Quality Management District (MDAQMD). 2000. Emissions Inventory Guidance: Mineral Handling and Processing Industries. April 1(
http://www.mdaqmd.ca.gov/Modules/ShowDocument.aspx?documentid=401

Blast Hole Drilling

$E = E_f \times N$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per hole drilled
N = Number of blast holes drilled per year

PM_{10} E_f = 0.68 pounds per hole
$PM_{2.5}$ E_f = 0.68 pounds per hole

Drilling Emissions

Duration	Units	PM_{10}	$PM_{2.5}$
Daily	lbs/day	147	147
Annual	tpy	7	7

Dust Entrainment from Blasting

E = k x N x 0.0005 x A^1.5

E = Particulate matter emissions rate in pounds per year
k = Particulate matter size factor
N = Number of blasts per year
A = Horizontal area shifted by each blast in square feet

k (PM_{10}) 0.52
k ($PM_{2.5}$) 0.52

N 799 (annual)
9 (daily)
A 288 square feet

Blasting Emissions

Duration	Units	PM_{10}	$PM_{2.5}$
Daily	lbs/day	11	11
Annual	tpy	1	1

Table M11B. Blasting Emission Calculations (continued)

Criteria Emissions from Blasting Explosives

E = Ef x A

E	=	Pollutant emissions rate in pounds per year
Ef	=	Emission factor in units of pounds of pollutant per ton of explosives detonated
A	=	Amount of explosive detonated throughout the year in tons

Emission Factors (lbs of pollutant per ton of explosive detonated)				
Explosive Type	Composition	CO	NOx	TOG
Black Powder	Potassium nitrate, charcoal, and sulfur	170	--	4.2
Smokeless Powder	Nitrocellulose	77	--	1.1
Dynamite, straight	Nitroglycerine, sodium nitrate, wood pulp, calcium carbonate	281	--	2.5
Dynamite, ammonia	Nitroglycerine, ammonium nitrate, sodium nitrate, wood pulp	63	--	1.3
Dynamite, gelatin	Nitroglycerine	104	53	0.7
ANFO	Ammonium nitrate, fuel oil	67	17	--
TNT	Trinitrotoluene	796	--	14.3
RDX	Cyclotrimethylenetrinitroamine	196	--	--
PETN	Pentaerylthritol tetranitrate	297	--	--

Note:
VOC emissions are considered negligible for all explosives.
TSP, PM10, and PM2.5 emissions are subsumed within the dust entrainment estimations.

Quantity: 1.5 pounds explosive/cubic yard

Annual Debris/Waste:

Mass	69,179	tons/year
Density	120	pounds/cubic foot
Volume	42,703	cubic yards/year

Daily Debris/Waste:

Mass	797	tons/day
Density	120	pounds/cubic foot
Volume	492	cubic yards/day

Criteria Pollutant Emissions

Explosive Used: ANFO
Amount of explosive: 32.0 tons/year
0.4 tons/day

	Daily	Annual
Pollutant	(lbs/day)	(tpy)
CO	24.7	1.1
NOx	6.3	0.3

Table M11C. Blasting and Drilling Pattern

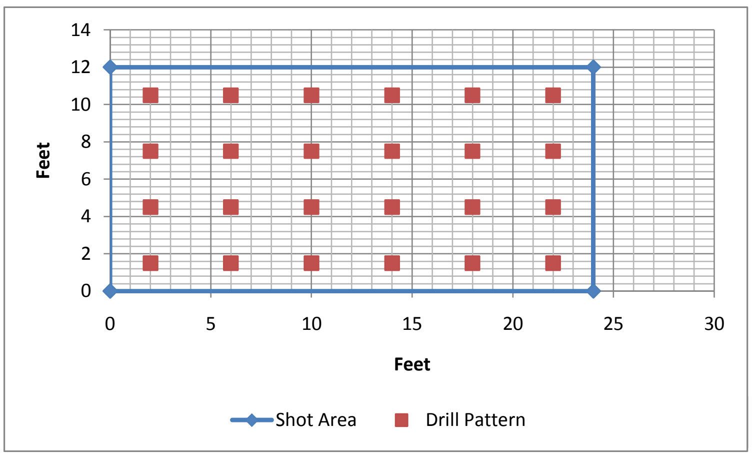
Copco 1 - Demolition

	Dimensions		
	Length (ft)	Width (ft)	Area (sq. ft.)
Shot Length x Width	24	12	288
Production Drill Pattern	4	3	12
Number of Holes per Shot	24		
Weeks Needed	17		
Shots per Week	47		
Shots per Day	9		
Total Shots	799		
Daily Number of Holes	216		
Total Number of Holes	19,176		

	Dimensions		
	Length (ft)	Width (ft)	Area (sq. ft.)
Shot Length x Width	40	20	800
Production Drill Pattern	4	3	12
Number of Holes per Shot	67		
Weeks Needed	17		
Shots per Week	47		
Shots per Day	9		
Total Shots	799		
Daily Number of Holes	600		
Total Number of Holes	53,267		

Note: Red text = calculated value

Source: Att No. 3 - Copco 1 Primary Dam Removal Assessment



General Procedures for Drilling and Blasting

1. Develop drill pattern (including number of holes to be drilled, depths and diameters of holes, etc.)
2. Develop sequence and pattern of multiple explosions (several small explosions comprise a single blast).
3. Blasting crews set the blasting caps, load the holes with explosives, stem the holes w/crushed stone, and connect each hole within the shot.

http://www.mdandb.com/blastanatomy.cfm

Table M12A. Summary of Unmitigated EMFAC2007 Emission Factors

								Emission Factors (g/mi) - 2019							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Construction Workers	0.551	0.588	4.680	0.487	0.004	0.041	0.021	0.008	0.013	0.027	0.019	0.002	0.005	351.872	0.033
Pick-up Trucks (Gasoline)	0.442	0.476	3.714	0.465	0.005	0.052	0.031	0.008	0.013	0.037	0.029	0.002	0.005	503.354	0.031
Pick-up Trucks (Diesel)	0.082	0.094	0.638	1.477	0.003	0.074	0.053	0.008	0.013	0.056	0.049	0.002	0.005	346.620	0.004
Heavy-Duty Diesel Trucks	0.628	0.715	2.737	7.691	0.018	0.317	0.253	0.036	0.028	0.254	0.233	0.009	0.012	1901.576	0.029
Source								Emission Factors (g/mi) - 2020							
Construction Workers	0.506	0.539	4.201	0.439	0.004	0.041	0.021	0.008	0.013	0.026	0.019	0.002	0.005	337.274	0.030
Pick-up Trucks (Gasoline)	0.413	0.444	3.396	0.423	0.005	0.052	0.031	0.008	0.013	0.037	0.029	0.002	0.005	503.380	0.029
Pick-up Trucks (Diesel)	0.081	0.092	0.630	1.482	0.003	0.073	0.052	0.008	0.013	0.055	0.048	0.002	0.005	346.726	0.004
Heavy-Duty Diesel Trucks	0.566	0.645	2.498	6.793	0.018	0.283	0.219	0.036	0.028	0.223	0.202	0.009	0.012	1899.853	0.026
Source								Emission Factors (g/mi) - 2023							
Construction Workers	0.387	0.412	2.867	0.312	0.004	0.040	0.020	0.008	0.013	0.026	0.018	0.002	0.005	319.237	0.023
Pick-up Trucks (Gasoline)	0.344	0.370	2.600	0.319	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.455	0.024
Pick-up Trucks (Diesel)	0.078	0.089	0.617	1.492	0.003	0.072	0.051	0.008	0.013	0.055	0.047	0.002	0.005	347.164	0.004
Heavy-Duty Diesel Trucks	0.434	0.494	1.984	4.916	0.018	0.213	0.148	0.036	0.028	0.158	0.137	0.009	0.012	1895.307	0.020
Source								Emission Factors (g/mi) - 2024							
Construction Workers	0.352	0.375	2.554	0.278	0.004	0.040	0.019	0.008	0.013	0.025	0.018	0.002	0.005	314.182	0.021
Pick-up Trucks (Gasoline)	0.325	0.349	2.412	0.291	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.489	0.023
Pick-up Trucks (Diesel)	0.076	0.086	0.611	1.493	0.003	0.070	0.050	0.008	0.013	0.053	0.046	0.002	0.005	347.107	0.004
Heavy-Duty Diesel Trucks	0.407	0.463	1.880	4.544	0.018	0.198	0.134	0.036	0.028	0.144	0.123	0.009	0.012	1894.343	0.019
Source								Emission Factors (g/mi) - 2025							
Construction Workers	0.322	0.343	2.297	0.248	0.004	0.040	0.019	0.008	0.013	0.025	0.018	0.002	0.005	309.680	0.019
Pick-up Trucks (Gasoline)	0.309	0.332	2.260	0.267	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.549	0.022
Pick-up Trucks (Diesel)	0.074	0.084	0.608	1.493	0.003	0.068	0.048	0.008	0.013	0.051	0.044	0.002	0.005	346.702	0.003
Heavy-Duty Diesel Trucks	0.386	0.439	1.800	4.261	0.018	0.187	0.122	0.036	0.028	0.134	0.113	0.009	0.012	1893.663	0.018

								Emission Factors (g/gal) - 2019							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	3.099	3.675	64.564	8.089	0.085	0.903	0.546	0.139	0.218	0.635	0.506	0.035	0.093	6853.123	0.535
Pick-up Trucks (Diesel)	2.391	2.721	18.554	42.953	0.096	2.139	1.542	0.233	0.365	1.633	1.419	0.058	0.156	7895.515	0.111
Heavy-Duty Gasoline Vehicles	38.397	41.971	1079.229	102.086	0.085	0.651	0.179	0.141	0.331	0.343	0.166	0.035	0.142	7040.659	3.104
Heavy-Duty Diesel Trucks	3.329	3.790	14.509	40.768	0.096	1.683	1.342	0.191	0.150	1.347	1.235	0.048	0.064	10080.002	0.155
								Emission Factors (g/gal) - 2020							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	2.765	3.302	59.094	7.358	0.085	0.904	0.547	0.139	0.218	0.636	0.507	0.035	0.094	6624.024	0.501
Pick-up Trucks (Diesel)	2.340	2.664	18.312	43.091	0.096	2.110	1.512	0.233	0.365	1.606	1.391	0.058	0.156	7623.113	0.109
Heavy-Duty Gasoline Vehicles	30.459	33.476	977.395	98.842	0.085	0.668	0.181	0.145	0.342	0.351	0.168	0.036	0.146	7226.011	2.641
Heavy-Duty Diesel Trucks	3.004	3.420	13.256	36.040	0.096	1.504	1.163	0.191	0.150	1.182	1.070	0.048	0.064	10080.002	0.140
								Emission Factors (g/gal) - 2023							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	2.023	2.474	45.355	5.560	0.085	0.909	0.551	0.140	0.219	0.639	0.511	0.035	0.094	6642.214	0.424
Pick-up Trucks (Diesel)	2.279	2.594	17.903	43.325	0.096	2.084	1.487	0.232	0.364	1.583	1.368	0.058	0.156	7623.112	0.106
Heavy-Duty Gasoline Vehicles	20.409	22.792	813.006	91.566	0.085	0.696	0.187	0.152	0.357	0.364	0.174	0.038	0.153	7516.216	2.127
Heavy-Duty Diesel Trucks	2.306	2.626	10.551	26.147	0.096	1.131	0.789	0.191	0.150	0.838	0.726	0.048	0.064	10079.996	0.107
								Emission Factors (g/gal) - 2024							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	1.820	2.249	42.095	5.076	0.085	0.910	0.552	0.140	0.219	0.641	0.512	0.035	0.094	6646.593	0.404
Pick-up Trucks (Diesel)	2.205	2.511	17.740	43.355	0.096	2.036	1.439	0.232	0.364	1.538	1.324	0.058	0.156	7623.115	0.102
Heavy-Duty Gasoline Vehicles	18.285	20.541	776.986	90.334	0.085	0.704	0.191	0.153	0.360	0.370	0.177	0.038	0.154	7579.538	2.025
Heavy-Duty Diesel Trucks	2.164	2.464	10.002	24.177	0.096	1.054	0.712	0.192	0.150	0.767	0.655	0.048	0.064	10080.007	0.101
								Emission Factors (g/gal) - 2025							
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	1.658	2.067	39.462	4.661	0.085	0.912	0.553	0.140	0.219	0.642	0.513	0.035	0.094	6650.133	0.387
Pick-up Trucks (Diesel)	2.150	2.448	17.664	43.395	0.096	1.989	1.392	0.233	0.365	1.495	1.281	0.058	0.156	7623.111	0.100
Heavy-Duty Gasoline Vehicles	14.981	17.039	710.425	89.275	0.085	0.717	0.196	0.155	0.365	0.377	0.182	0.039	0.157	7694.584	1.866
Heavy-Duty Diesel Trucks	2.055	2.339	9.581	22.680	0.096	0.993	0.652	0.192	0.150	0.712	0.599	0.048	0.064	10080.004	0.095

Notes:
Construction workers emissions only include LDA, LDT1, and LDT2 vehicle types, based on guidance from URBEMIS2007 User's Guide.
CO2 emission factors for construction workers adjusted to reflect the Pavley and LCFS using CARB's Pavley post-processor.
Pick-up trucks use LDT2 emission factors.

Table M12B. MOBILE6.2 Exhaust Emission Factors

	Emission Factors (g/mi) - 2019												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	0.530	10.446	0.408	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	467.9
Pick-Up Trucks (Gasoline)	0.596	10.789	0.473	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.228	0.486	0.295	0.006	0.039	0.018	0.008	0.013	0.024	0.017	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.498	8.250	0.713	0.016	0.036	0.015	0.009	0.013	0.021	0.013	0.002	0.005	905.9
Heavy-Duty Diesel Trucks	0.271	0.517	1.921	0.013	0.072	0.033	0.026	0.013	0.042	0.030	0.007	0.005	1395.4
	Emission Factors (g/mi) - 2020												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	0.504	10.304	0.396	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	468.8
Pick-Up Trucks (Gasoline)	0.564	10.613	0.459	0.009	0.024	0.004	0.008	0.013	0.011	0.003	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.212	0.465	0.271	0.006	0.038	0.017	0.008	0.013	0.023	0.016	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.459	8.206	0.637	0.016	0.035	0.014	0.009	0.013	0.020	0.012	0.002	0.005	905.6
Heavy-Duty Diesel Trucks	0.266	0.470	1.686	0.013	0.069	0.030	0.026	0.013	0.039	0.027	0.007	0.005	1395.6
	Emission Factors (g/mi) - 2022												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	0.461	10.125	0.373	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	468.8
Pick-Up Trucks (Gasoline)	0.511	10.400	0.434	0.009	0.024	0.004	0.008	0.013	0.011	0.003	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.184	0.429	0.229	0.006	0.035	0.014	0.008	0.013	0.021	0.013	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.393	8.126	0.492	0.016	0.033	0.012	0.009	0.013	0.018	0.011	0.002	0.005	905.6
Heavy-Duty Diesel Trucks	0.257	0.396	1.312	0.013	0.063	0.024	0.026	0.013	0.034	0.022	0.007	0.005	1395.6

	Emission Factors (g/gal) - 2019												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	10.379	204.664	7.998	0.168	0.477	0.075	0.157	0.245	0.213	0.070	0.039	0.104	9168.2
Pick-Up Trucks (Gasoline)	10.367	187.800	8.234	0.165	0.422	0.065	0.139	0.218	0.188	0.061	0.035	0.092	8983.0
Pick-Up Trucks (Diesel)	3.876	8.262	5.015	0.095	0.660	0.3111	0.136	0.213	0.410	0.286	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	4.893	81.036	7.008	0.161	0.351	0.143	0.085	0.123	0.203	0.130	0.021	0.052	8898.9
Heavy-Duty Diesel Trucks	2.102	4.017	14.910	0.101	0.559	0.257	0.204	0.097	0.329	0.236	0.051	0.041	10833.6
	Emission Factors (g/gal) - 2020												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	9.860	201.489	7.742	0.168	0.476	0.075	0.156	0.244	0.211	0.069	0.039	0.104	9166.8
Pick-Up Trucks (Gasoline)	9.815	184.734	7.997	0.165	0.422	0.065	0.139	0.218	0.187	0.060	0.035	0.092	8983.0
Pick-Up Trucks (Diesel)	3.604	7.905	4.607	0.095	0.638	0.289	0.136	0.213	0.389	0.265	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	4.514	80.624	6.264	0.161	0.342	0.134	0.085	0.123	0.194	0.121	0.021	0.052	8898.2
Heavy-Duty Diesel Trucks	2.061	3.647	13.079	0.101	0.532	0.230	0.204	0.097	0.304	0.212	0.051	0.041	10828.8
	Emission Factors (g/gal) - 2022												
Source	VOC	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2
Construction Worker	9.011	197.974	7.299	0.168	0.475	0.074	0.156	0.244	0.211	0.069	0.039	0.104	9167.5
Pick-Up Trucks (Gasoline)	8.890	181.029	7.557	0.165	0.421	0.064	0.139	0.218	0.187	0.060	0.035	0.092	8983.9
Pick-Up Trucks (Diesel)	3.128	7.293	3.893	0.095	0.593	0.245	0.136	0.213	0.349	0.224	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	3.859	79.841	4.830	0.161	0.326	0.119	0.085	0.123	0.181	0.107	0.021	0.052	8898.2
Heavy-Duty Diesel Trucks	1.997	3.072	10.181	0.101	0.488	0.186	0.204	0.097	0.264	0.172	0.051	0.041	10828.8

Appendix N
Greenhouse Gas Emission Impacts

N.1 Assessment Methods

This section describes the methodology used to develop the greenhouse gas (GHG) emission inventories and the comparison of the analysis results for the project site activities to the California Environmental Quality Act significance thresholds.

N.1.1 Emission Calculation Methodology

The GHG emission sources that were estimated as part of this analysis include the following:

- Exhaust from off-road (onsite) mobile construction equipment and stationary sources (e.g., generators)
- Exhaust from on-road (offsite) mobile vehicles, including haul trucks and construction worker commuting
- Methane ($CH_{4)}$ emissions that could occur from impounded water at the reservoirs
- Possible emissions that could occur from replace the hydroelectric dams with non-renewable power

Emissions of carbon dioxide (CO_2), CH_4, and nitrous oxide (N_2O) were estimated to evaluate GHG impacts. Non-CO_2 pollutants have global warming potential (GWP) factors that reflect the degree to which these pollutants affect climate change, as compared to CO_2. The product of each GHG emissions and its GWP is known as Carbon Dioxide equivalent (CO_2e). The value of GWPs is continually being modified by the Intergovernmental Panel on Climate Change (IPCC) as climate change science is refined. Although the IPCC is currently working on the Fifth Assessment Report, most mandatory and voluntary reporting registries require the use of the GWPs published in the Second Assessment Report (IPCC 1996); therefore, the GWPs from the Second Assessment Report were used to maintain consistency with the international standard.

Annual emissions for each year of construction were estimated from appropriate emission factors, number of facilities and features being worked, and the associated schedules that were provided by the project consultants. The following sections provide additional discussion of emission estimation methodologies used for each source group.

N.1.1.1 On-Site (Off-Road) Equipment Engine Exhaust Emissions

Emissions would occur from the combustion of fuel during operation of the off-road construction equipment at each of the dams. As was previously stated, separate emission factor models (i.e., OFFROAD2007 and NONROAD2008a) are used to estimate emissions in California and Oregon.

Preliminary estimates of the type, size (horsepower), and quantity of construction proposed to be used at each of the dam locations was provided by the project consultants. Engine load factors are also incorporated into the emission factor models. Emission factors for each piece of equipment were then selected based on the equipment type (e.g., cranes, excavators, loaders, etc.) and the engine size. It was conservatively assumed that all equipment located at a dam site could operate simultaneously for the entire shift. Iron Gate would have a maximum operating schedule of 14 hours per day, Copco 1 would operate 16 hours per day, and Copco 2 and J.C. Boyle would operate eight hours per day. The total hours of operation for each piece of equipment was also provided with the equipment list provided by the project consultants. Annual emissions were then calculated from the total hours of operation.

In addition to the mobile construction equipment, several stationary generators would be present at each of the dam locations to provide power for electric-operated equipment. Emission factors from Chapter 3.3 (U.S. Environmental Protection Agency 1995) of AP-42 were used to estimate emissions from these generators.

N.1.1.2 Off-Site (On-Road) Haul Truck Engine Exhaust Emissions and Paved Road Dust

The haul truck engine exhaust emissions were calculated based on EMFAC2007 and MOBILE6.2 emission factors for heavy-duty diesel trucks in Siskiyou County, California and Klamath County, Oregon, respectively. Information on the project total round trips was provided by the project consultants. The total project trips were assumed to occur evenly throughout the project schedule. The total vehicle miles traveled was determined from the number of trips and estimated distance to haul each component (e.g., earth, concrete, metal, etc.).

Emission factors vary by year based on changes in the vehicle fleet mix by older engines retiring from service and improved emission control technologies and standards in newer engines joining the fleet. As a result, two different emission factors are provided by location (state) and pollutant to reflect these changes in the fleet mix.

N.1.1.3 Construction Worker Commuting

Emissions associated with construction workers commuting to and from the various dam locations were also estimated for each alternative. It was assumed that construction worker vehicles would consist of a mix of passenger cars and light-duty trucks. The combination of diesel and gasoline (catalyst and non-catalyst) vehicles from the various emission factor models was retained in the emission factor estimates. As explained in

Section N.1.1.2 for trucks, the EMFAC2007 and MOBILE6.2 emission factor models were used to estimate emissions.

N.1.1.4 Methane Emissions from Reservoirs

Methane emissions could also occur from impounded water at the reservoirs. The Karuk Tribe (2006) estimated the total amount of CH_4 released from Keno, J.C. Boyle, Copco, and Iron Gate reservoirs in its comments on the Draft Environmental Impact Statement (EIS) for relicensing and/or decommissioning of the Klamath Hydroelectric Project. The emissions estimation method presented by the Karuk Tribe was adapted for this analysis to estimate CH_4 emissions from impounded water. Emissions were estimated by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality).

N.1.1.5 Power Replacement

GHG emissions could also occur in the event of any changes in renewable power from the Four Facilities. Since the exact renewable power mix that could exist when the dams are removed, emissions were estimated in two ways: 1) assuming that the existing power mix would be in place and 2) assuming that PacifiCorp met the California Renewable Portfolio Standard (RPS) goal of 33 percent. Emission factors from Emissions & Generation Resource Integrated Database (eGRID) for the PacifiCorp Power Control Area were used to estimate a worst-case scenario assuming that the power grid would not change between now and 2020. Emission factors were then developing assuming that the renewable power mix would increase from approximately nine percent (current mix) to 33 percent by 2020.

The Federal Energy Regulatory Commission EIS (2007) provided power generation estimates for the different alternatives. These annual average power estimates were used in the analysis to estimate emissions that could occur from power replacement.

N.2 Emission Inventories

Emission inventories were completed for each of the dam locations and alternatives as described in the previous sections. Table N-1 summarizes emissions that could occur from dam removal activities or the construction of fish passage, as well as possible power replacement emissions. The table does not include CH_4 emissions that would occur from impounded water in the reservoirs.

Table N-1. Impact Summary Table (Without Methane Generation from Reservoirs)

Alternative	Emissions (metric tons CO_2e/year)		
	Deconstruction	Power Replacement	
		(Current Resource Mix)	(33% RPS)
2	8,747	396,575	341,539
3	7,840	396,575	341,539
4	1,600	87,525	75,431
5	7,789	139,644	120,320

Key:
CO_2e = carbon dioxide equivalent

Table N-2 summarizes power replacement emissions with CH_4 generation from the reservoirs. The Karuk Tribe (2006) estimated a range of emissions that could occur based on the conditions that could occur; therefore, Table N-2 shows the predicted range of emissions that could occur based on the amount of CH_4 that could be emitted from the reservoirs.

In Alternatives 2 and 3, the dams would be removed in their entirety and the reservoirs would cease to exist; therefore, the total expected impact from power replacement would be reduced by the amount of CH_4 that would no longer be emitted from the impounded water. Although the dams would remain in place in Alternative 4, the amount of power that could be produced would be reduced from current conditions because water would be needed to support fish passage. The amount of CH_4 emitted from the reservoirs is added to the emissions that could occur from the expected reduction in renewable power. In Alternative 5, the J.C. Boyle Reservoir would remain, but emissions from the other reservoirs would be eliminated. As with Alternative 4, CH_4 emissions from the reservoirs are added to the emissions that could occur from power replacement.

Table N-2. Impact Summary Table (With Methane Generation from Reservoirs)

Alternative	Power Replacement and CH_4 from Impounded Reservoirs Emissions (metric tons CO_2e/year)			
	(Current Resource Mix)		(33% RPS)	
	Low[1]	High[2]	Low[1]	High[2]
2	392,575	382,575	337,539	327,539
3	392,575	382,575	337,539	327,539
4	91,525	101,525	79,431	89,431
5	140,344	142,644	121,020	123,320

Notes:
[1] Low power replacement refers to minimum CH_4 emissions predicted to be emitted by the reservoirs.
[2] High power replacement refers to maximum CH_4 emissions predicted to be emitted by the reservoirs.
Key:
CH_4 = methane
CO_2e = carbon dioxide equivalent

Detailed emission inventories for each of the alternatives are included as attachments to this appendix.

N.3 References

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U.S. Environmental Protection Agency. 1995. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42, Fifth Edition. Accessed on January 31, 2011. Available at: http://www.epa.gov/ttn/chief/ap42/.

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Table N1A. Summary of Annual Emissions by Alternative (tons per one year)

	Annual Emissions (MT/yr)			2020 Annual Emissions (MTCO2e/yr)					Below Threshold
	CO2	CH4	N2O	CO2	CH4	N2O	Total	Amortized	
Alternative 2	8,551	0.31	0.00	8,551	6	0	8,558	285	1,442
Alternative 3	7,742	0.30	0.00	7,742	6	0	7,748	258	2,252
Alternative 4	1,599	0.06	0.00	1,599	1	0	1,600	53	8,400
Alternative 5	6,439	0.29	0.00	6,439	6	0	6,445	215	3,555

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
MT = metric tons
N2O = nitrous oxide

Project Lifetime	30	years
Project Threshold	10,000	MTCO2e/yr

2020 Emissions Target 427 million MTCO2e

	CO2	CH4	N2O
Global Warming Potential	1	21	310

Table N1B. Alternative 2 Annual Emissions Summary (tons per one year)

	Annual Emissions (MT/yr)			2020 Annual Emissions (MTCO2e/yr)				
	CO2	**CH4**	**N2O**	**CO2**	**CH4**	**N2O**	**Total**	**Amortized**
Iron Gate		**2020**				**2020**		
Construction Equipment	3,840.37	0.19	n/a	3,840	4	--	3,844	128
Haul Trucks	227.98	0.00	n/a	228	0	--	228	8
Employee Commuting	37.74	0.00	n/a	38	0	--	38	1
TOTAL	4,106.09	0.20	0.00	4,106	4	0	4,110	137
Copco 1		**2020**				**2020**		
Construction Equipment	1,410.41	0.06	n/a	1,410	1	--	1,412	47
Haul Trucks	20.02	0.00	n/a	20	0	--	20	1
Employee Commuting	28.92	0.00	n/a	29	0	--	29	1
TOTAL	1,459.35	0.06	0.00	1,459	1	0	1,461	49
Copco 2		**2020**				**2020**		
Construction Equipment	894.43	0.04	n/a	894	1	--	895	30
Haul Trucks	15.43	0.00	n/a	15	0	--	15	1
Employee Commuting	59.72	0.00	n/a	60	0	--	60	2
TOTAL	969.58	0.05	0.00	970	1	0	971	32
J.C. Boyle		**2020**				**2020**		
Construction Equipment	1,974.35	0.00	n/a	1,974	0	--	1,974	66
Haul Trucks	12.28	n/a	n/a	12	0	--	12	0
Employee Commuting	29.75	n/a	n/a	30	0	--	30	1
TOTAL	2,016.37	0.00	0.00	2,016	0	0	2,016	67
Project Total	8,551.40	0.31	0.00	8,551	6	0	8,558	285
California Total	6,535.03	0.31	0.00	6,535	6	0	6,542	218
Oregon Total	2,016.37	0.00	0.00	2,016	0	0	2,016	67

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
MT = metric tons
N2O = nitrous oxide

	CO2	CH4	N2O
Global Warming Potential	1	21	310

Table N1C. Alternative 3 Annual Emissions Summary (tons per one year)

	Annual Emissions (MT/yr)			2020 Annual Emissions (MTCO2e/yr)				
	CO2	**CH4**	**N2O**	**CO2**	**CH4**	**N2O**	**Total**	**Amortized**
Iron Gate	**2020**			**2020**				
Construction Equipment	3,840.37	0.19	n/a	3,840	4	0	3,844	128
Haul Trucks	237.58	0.00	n/a	238	0	0	238	8
Employee Commuting	35.85	0.00	n/a	36	0	0	36	1
TOTAL	4,113.80	0.20	0.00	4,114	4	0	4,118	137
Copco 1	**2020**			**2020**				
Construction Equipment	1,410.41	0.06	n/a	1,410	1	0	1,412	47
Haul Trucks	21.75	0.00	n/a	22	0	0	22	1
Employee Commuting	26.35	0.00	n/a	26	0	0	26	1
TOTAL	1,458.51	0.06	0.00	1,459	1	0	1,460	49
Copco 2	**2020**			**2020**				
Construction Equipment	742.58	0.03	n/a	743	1	0	743	25
Haul Trucks	26.60	0.00	n/a	27	0	0	27	1
Employee Commuting	59.72	0.00	n/a	60	0	0	60	2
TOTAL	828.90	0.04	0.00	829	1	0	830	28
J.C. Boyle	**2020**			**2020**				
Construction Equipment	1,280.87	0.00	n/a	1,281	0	0	1,281	43
Haul Trucks	32.96	0.00	n/a	33	0	0	33	1
Employee Commuting	27.10	n/a	n/a	27	0	0	27	1
TOTAL	1,340.93	0.00	0.00	1,341	0	0	1,341	45
Project Total	7,742.14	0.30	0.00	7,742	6	0	7,748	258
California Total	6,401.21	0.30	0.00	6,401	6	0	6,408	214
Oregon Total	1,340.93	0.00	0.00	1,341	0	0	1,341	45

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
MT = metric tons
N2O = nitrous oxide

	CO2	CH4	N2O
Global Warming Potential	1	21	310

Table N1D. Alternative 4 Annual Emissions Summary (tons per one year)

	Annual Emissions (MT/yr)			2020 Annual Emissions (MTCO2e/yr)				
	CO2	**CH4**	**N2O**	**CO2**	**CH4**	**N2O**	**Total**	**Amortized**
Iron Gate	**2023**			**2023**				
Construction Equipment	1,410.65	0.05	n/a	1,411	1	0	1,412	47
Haul Trucks	89.55	0.00	n/a	90	0	0	90	3
Employee Commuting	98.84	0.01	n/a	99	0	0	99	3
TOTAL	1,599.04	0.06	0.00	1,599	1	0	1,600	53
Copco 1	**2025**			**2025**				
Construction Equipment	1,158.54	0.04	n/a	1,159	1	0	1,159	39
Haul Trucks	85.35	0.00	n/a	85	0	0	85	3
Employee Commuting	62.71	0.00	n/a	63	0	0	63	2
TOTAL	1,306.60	0.04	0.00	1,307	1	0	1,308	44
Copco 2	**2024**			**2024**				
Construction Equipment	253.44	0.01	n/a	253	0	0	254	8
Haul Trucks	29.52	0.00	n/a	30	0	0	30	1
Employee Commuting	19.04	0.00	n/a	19	0	0	19	1
TOTAL	302.01	0.01	0.00	302	0	0	302	10
J.C. Boyle	**2022**			**2022**				
Construction Equipment	666.90	0.00	n/a	667	0	0	667	22
Haul Trucks	102.82	0.00	n/a	103	0	0	103	3
Employee Commuting	50.35	n/a	n/a	50	0	0	50	2
TOTAL	820.08	0.00	0.00	820	0	0	820	27
Project Maximum	1,599.04	0.06	0.00	1,599	1	0	1,600	53
California Maximum	1,599.04	0.06	0.00	1,599	1	0	1,600	53
Oregon Maximum	820.08	0.00	0.00	820	0	0	820	27

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
MT = metric tons
N2O = nitrous oxide

	CO2	CH4	N2O
Global Warming Potential	1	21	310

Table N1E. Alternative 5 Annual Emissions Summary (tons per one year)

	Annual Emissions (MT/yr)			2020 Annual Emissions (MTCO2e/yr)				
	CO2	**CH4**	**N2O**	**CO2**	**CH4**	**N2O**	**Total**	**Amortized**
Iron Gate	**2020**			**2020**				
Construction Equipment	3,840.37	0.19	n/a	3,840	4	0	3,844	128
Haul Trucks	13.34	0.00	n/a	13	0	0	13	0
Employee Commuting	90.79	0.01	n/a	91	0	0	91	3
TOTAL	3,944.50	0.20	0.00	3,944	4	0	3,949	132
Copco 1	**2020**			**2020**				
Construction Equipment	1,410.41	0.06	n/a	1,410	1	0	1,412	47
Haul Trucks	3.53	0.00	n/a	4	0	0	4	0
Employee Commuting	59.72	0.00	n/a	60	0	0	60	2
TOTAL	1,473.67	0.07	0.00	1,474	1	0	1,475	49
Copco 2	**2020**			**2020**				
Construction Equipment	253.91	0.02	n/a	254	1	0	254	8
Haul Trucks	0.46	0.00	n/a	0	0	0	0	0
Employee Commuting	14.15	0.00	n/a	14	0	0	14	0
TOTAL	268.51	0.03	0.00	269	1	0	269	9
J.C. Boyle	**2020**			**2020**				
Construction Equipment	666.88	0.00	n/a	667	0	0	667	22
Haul Trucks	73.81	0.00	n/a	74	0	0	74	2
Employee Commuting	11.24	n/a	n/a	11	0	0	11	0
TOTAL	751.92	0.00	0.00	752	0	0	752	25
Project Total	6,438.60	0.29	0.00	6,439	6	0	6,445	215
California Total	5,686.68	0.29	0.00	5,687	6	0	5,693	190
Oregon Total	751.92	0.00	0.00	752	0	0	752	25

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
MT = metric tons
N2O = nitrous oxide

	CO2	CH4	N2O
Global Warming Potential	1	21	310

Table N2A. Summary of Alternative 2 Off-Road Construction Emissions

	(metric tons)		CO2e (metric tons)		
	CO2	CH4	CO2	CH4	Total
Iron Gate	3,840.4	0.2	3,840.4	4.0	3,844.4
Copco 1	1,410.4	0.1	1,410.4	1.3	1,411.7
Copco 2	894.4	0.0	894.4	0.9	895.3
J.C. Boyle	1,974.3	0.0	1,974.3	0.0	1,974.3
Total	8,119.6	0.3	8,119.6	6.2	8,125.8
California %	76%	100%	76%	100%	76%
Oregon %	24%	0%	24%	0%	24%

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent

Table N2B. Off-Road Construction Emissions for Iron Gate Dam (Alternative 2)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

Global Warming Potential
CO2 1
CH4 21

Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
					CO2	CH4	CO2	CH4	CO2	CH4
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	163.24	0.01	63.54	0.00	63.54	0.07
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	208.07	0.02	31.43	0.00	31.43	0.05
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX1200	Excavators	646	Diesel	234.10	0.01	702.90	0.03	702.90	0.69
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	246.84	0.01	2,495.40	0.12	2,495.40	2.59
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	240.08	0.02	193.60	0.02	193.60	0.32
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	6,624.02	0.50	18.47	0.00	18.47	0.03
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	7,623.11	0.11	11.24	0.00	11.24	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	7,623.11	0.11	13.70	0.00	13.70	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	323.94	0.02	65.87	0.00	65.87	0.08
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	521.64	--	7.88	--	7.88	--
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	489.89	--	11.95	--	11.95	--
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	275.84	0.01	224.37	0.01	224.37	0.21
						Total	3,840.37	0.19	3,840.37	4.04
								Total CO2e	3,844.41	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N2C. Off-Road Construction Equipment Emissions for Copco 1 (Alternative 2)

Maximum Daily Work Hours 8 hours/shift

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Global Warming Potential

CO2	1
CH4	21

Quantity					2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	CO2	CH4	CO2	CH4	CO2	CH4
1	1	Crane - crawler, 150-200 ton	335	Diesel	163.24	0.01	68.25	0.00	68.25	0.08
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	208.07	0.02	33.76	0.00	33.76	0.05
1	0	Excavator - hydraulic ram	321	Diesel	211.85	0.01	42.44	0.00	42.44	0.04
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	287.66	0.01	78.80	0.00	78.80	0.08
3	0	Excavator - <20,000 lb	168	Diesel	290.62	0.02	91.40	0.01	91.40	0.11
1	0	Loader - WA250 IT	138	Diesel	275.32	0.02	23.71	0.00	23.71	0.03
1	0	Loader - WA450	273	Diesel	214.82	0.01	36.60	0.00	36.60	0.04
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	246.84	0.01	100.12	0.00	100.12	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	6624.02	0.50	60.21	0.00	60.21	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	7623.11	0.11	36.65	0.00	36.65	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	7623.11	0.11	44.66	0.00	44.66	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	6624.02	0.50	89.90	0.01	89.90	0.14
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	323.94	0.02	70.75	0.00	70.75	0.09
1	1	Engine generator, 6.5 KW	13	Diesel	521.64	--	8.46	--	8.46	--
1	1	Engine generator, 10 KW	21	Gasoline	489.89	--	12.84	--	12.84	--
4	4	Air compressor, 850-1200 cfm	106	Diesel	305.37	0.02	161.59	0.01	161.59	0.19
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	282.17	0.01	409.89	0.01	409.89	0.20
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	305.37	0.02	40.40	0.00	40.40	0.05
						Total	1,410.41	0.06	1,410.41	1.32
								Total CO2e	1,411.73	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N2D. Off-Road Construction Emissions for Copco 2 (Alternative 2)

Maximum Daily Work Hours 8 hours

							Peak Daily	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	12,111	1,096	8	163.24	0.01	59.94	0.00	59.94	0.07
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	208.07	0.02	51.50	0.00	51.50	0.08
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	24,408	1,808	8	211.85	0.01	122.95	0.01	122.95	0.12
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	29,548	2,192	8	211.85	0.01	149.07	0.01	149.07	0.15
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	270.06	0.01	145.63	0.01	145.63	0.16
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	214.82	0.01	13.06	0.00	13.06	0.01
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	11,686	1,408	8	246.84	0.01	144.23	0.01	144.23	0.15
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	301.16	0.02	36.12	0.00	36.12	0.05
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	7623.11	0.11	32.09	0.00	32.09	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	7623.11	0.11	19.55	0.00	19.55	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	323.94	0.02	1.81	0.00	1.81	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	521.64	--	22.30	--	22.30	--
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	489.89	--	22.55	--	22.55	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	2,367	1,096	8	305.37	0.02	20.08	0.00	20.08	0.02
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	6,313	2,192	8	305.37	0.02	53.55	0.00	53.55	0.06
									Total	894.43	0.04	894.43	0.88
											Total CO2e	895.32	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Global Warming Potential	
CO2	1
CH4	21

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N2E. Off-Road Construction Emissions for JC Boyle (Alternative 2)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	23,603	2,136	8	228.13	--	163.24	--	163.24	--
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	3,256	800	8	228.14	--	23.73	--	23.73	--
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Diesel	Diesel Excavators	321	57,672	4,272	8	316.47	--	433.98	--	433.98	--
2	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	57,587	4,272	8	316.47	--	433.98	--	433.98	--
1	Hydraulic excavator, 6 cy	Diesel	Diesel Excavators	513	11,014	488	8	316.47	--	79.23	--	79.23	--
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	11,912	1,504	8	316.46	--	117.09	--	117.09	--
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	16,600	2,000	8	316.48	--	262.68	--	262.68	--
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	9,280	1,000	8	316.48	--	75.32	--	75.32	--
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	10,177.90	--	31.27	--	31.27	--
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	10,177.90	--	38.11	--	38.11	--
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	12,582	2,104	8	316.49	--	116.53	--	116.53	--
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	521.64	--	14.48	--	14.48	--
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	489.89	--	19.59	--	19.59	--
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	5,754	2,136	8	351.37	--	45.03	--	45.03	--
2	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	12,303	4,272	8	351.37	--	120.09	--	120.09	--
									Total	1,974.35	0.00	1,974.35	0.00
											Total CO2e	1,974.35	

Global Warming Potential	
CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table N2F. Construction Worker Commute Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	45	47	Oregon
Copco 1	56	78	California
Copco 2	40	69	California
Iron Gate	80	83	California

	Annual Emissions, metric tons/year (2020)		
Dam	**CO2**	**CH4**	**N2O**
J.C. Boyle	29.75	n/a	n/a
Copco 1	28.92	0.00	n/a
Copco 2	59.72	0.00	n/a
Iron Gate	37.74	0.00	n/a
Total	156.13	0.01	0.00
GWP	1	21	310
Dam	**CO2e Emissions, MTCO2e/year**		
J.C. Boyle	29.75	n/a	n/a
Copco 1	28.92	0.04	n/a
Copco 2	59.72	0.08	n/a
Iron Gate	37.74	0.05	n/a
Total	156.13	0.18	0.00
Total CO2e	**156.30**		
California Total	**126.56**		81%
Oregon Total	**29.75**		19%

Note:
Emission factors for N2O are not available in the EMFAC and MOBILE6 emission factor models.
Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GWP = global warming potential
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Table N2G. Annual Haul Truck Emissions
Alternative 2 - Full Facilities Removal (Proposed Action)

Dam	Waste Material	Annual Trips	Round Trip Distance (mi)	Annual Emissions (tons per year) - 2020			CO2e Emissions (MTCO2e/year)			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
J.C. Boyle	Earth	8,500	1	11.86	n/a	n/a	12	n/a	n/a	12
	Concrete	2,600	3	10.89	n/a	n/a	11	n/a	n/a	11
	Metal	430	44	26.40	n/a	n/a	26	n/a	n/a	26
	Building Waste	200	44	12.28	n/a	n/a	12	n/a	n/a	12
	J.C. Boyle Subtotal	11,730	92	61.43	0.00	0.00	61	0.00	0.00	61
Copco 1 (California)	Concrete	4,000	2	15.20	0.00	n/a	15	0.0044	n/a	15
	Metal	170	62	20.02	0.00	n/a	20	0.0058	n/a	20
	Building Waste	30	62	3.53	0.00	n/a	4	0.0010	n/a	4
	Copco 1 Subtotal	4,200	126	38.76	0.00	0.00	39	0.011	0.00	39
Copco 2 (California)	Earth	90	2	0.34	0.00	n/a	0	0.00010	n/a	0
	Concrete (dam)	400	2	1.52	0.00	n/a	2	0.00044	n/a	2
	Concrete (plant)	0	0	0.00	0.00	n/a	0	0	n/a	0
	Metal (dam)	45	62	5.30	0.00	n/a	5	0.0015	n/a	5
	Metal (plant)	145	56	15.43	0.00	n/a	15	0.0045	n/a	15
	Building Waste	60	56	6.38	0.00	n/a	6	0.0019	n/a	6
	Wood-stave planks	45	240	20.52	0.00	n/a	21	0.0060	n/a	21
	Copco 2 Subtotal	785	418	49.49	0.00	0.00	49	0.014	0.00	50
Iron Gate (California)	Earth	60,000	2	227.98	0.00	n/a	228	0.066	n/a	228
	Concrete	750	2	2.85	0.00	n/a	3	0.00083	n/a	3
	Metal	130	54	13.34	0.00	n/a	13	0.0039	n/a	13
	Building Waste	40	54	4.10	0.00	n/a	4	0.0012	n/a	4
	Iron Gate Subtotal	60,920	112	248.27	0.00	0.00	248	0.072	0.00	248
	Grand Total	**77,635**	**748**	**397.95**	**0.0047**	**0.00**	**398**	**0.10**	**0.00**	**398**
	California Total	**65,905**	**656**	**337**	**0.0047**	**0.00**	**337**	**0.10**	**0.00**	**337**
	Oregon Total	**11,730**	**92**	**61**	**0.00**	**0.00**	**61**	**0.00**	**0.00**	**61**
	California %	**85%**	**88%**	**85%**	**100%**	**0%**	**85%**	**100%**	**0%**	**85%**
	Oregon %	**15%**	**12%**	**15%**	**0%**	**0%**	**15%**	**0%**	**0%**	**15%**

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
mi = miles
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Global Warming Potential

CO2	1
CH4	21
N2O	310

Source:
IPCC 1996 - Second Assessment Report

Table N3A. Summary of Alternative 3 Off-Road Construction Emissions

	(metric tons)		CO2e (metric tons)		
	CO2	CH4	CO2	CH4	Total
Iron Gate	3,840.4	0.2	3,840.4	4.0	3,844.4
Copco 1	1,410.4	0.1	1,410.4	1.3	1,411.7
Copco 2	742.6	0.0	742.6	0.7	743.3
J.C. Boyle	1,280.9	0.0	1,280.9	0.0	1,280.9
Total	7,274.2	0.3	7,274.2	6.1	7,280.3
California %	82%	100%	82%	100%	82%
Oregon %	18%	0%	18%	0%	18%

Note:

Alternative 3 includes full removal of Iron Gate and Copco 1 and partial removal of Copco 2 and JC Boyle.

Key:

CH4 = methane

CO2 = carbon dioxide

CO2e = carbon dioxide equivalent

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Table N3B. Off-Road Construction Emissions for Iron Gate Dam (Alternative 3)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

Global Warming Potential

CO2	1
CH4	21

					2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	CO2	CH4	CO2	CH4	CO2	CH4
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	163.24	0.01	63.54	0.00	63.54	0.07
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	208.07	0.02	31.43	0.00	31.43	0.05
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX1200	Excavators	646	Diesel	234.10	0.01	702.90	0.03	702.90	0.69
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	246.84	0.01	2,495.40	0.12	2,495.40	2.59
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	240.08	0.02	193.60	0.02	193.60	0.32
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	6,624.02	0.50	18.47	0.00	18.47	0.03
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	7,623.11	0.11	11.24	0.00	11.24	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	7,623.11	0.11	13.70	0.00	13.70	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	323.94	0.02	65.87	0.00	65.87	0.08
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	521.64	--	7.88	--	7.88	--
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	489.89	--	11.95	--	11.95	--
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	275.84	0.01	224.37	0.01	224.37	0.21
						Total	3,840.37	0.19	3,840.37	4.04
								Total CO2e	3,844.41	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N3C. Off-Road Construction Equipment Emissions for Copco 1 (Alternative 3)

Maximum Daily Work Hours 8 hours/shift

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Global Warming Potential
CO2 1
CH4 21

Quantity					2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	CO2	CH4	CO2	CH4	CO2	CH4
1	1	Crane - crawler, 150-200 ton	335	Diesel	163.24	0.01	68.25	0.00	68.25	0.08
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	208.07	0.02	33.76	0.00	33.76	0.05
1	0	Excavator - hydraulic ram	321	Diesel	211.85	0.01	42.44	0.00	42.44	0.04
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	287.66	0.01	78.80	0.00	78.80	0.08
3	0	Excavator - <20,000 lb	168	Diesel	290.62	0.02	91.40	0.01	91.40	0.11
1	0	Loader - WA250 IT	138	Diesel	275.32	0.02	23.71	0.00	23.71	0.03
1	0	Loader - WA450	273	Diesel	214.82	0.01	36.60	0.00	36.60	0.04
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	246.84	0.01	100.12	0.00	100.12	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	6624.02	0.50	60.21	0.00	60.21	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	7623.11	0.11	36.65	0.00	36.65	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	7623.11	0.11	44.66	0.00	44.66	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	6624.02	0.50	89.90	0.01	89.90	0.14
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	323.94	0.02	70.75	0.00	70.75	0.09
1	1	Engine generator, 6.5 KW	13	Diesel	521.64	--	8.46	--	8.46	--
1	1	Engine generator, 10 KW	21	Gasoline	489.89	--	12.84	--	12.84	--
4	4	Air compressor, 850-1200 cfm	106	Diesel	305.37	0.02	161.59	0.01	161.59	0.19
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	282.17	0.01	409.89	0.01	409.89	0.20
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	305.37	0.02	40.40	0.00	40.40	0.05
					Total		1,410.41	0.06	1,410.41	1.32
								Total CO2e	1,411.73	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N3D. Off-Road Construction Emissions for Copco 2 (Alternative 3)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	9,989	904	8	163.24	0.01	49.44	0.00	49.44	0.06
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	7,749	1,904	8	208.07	0.02	51.50	0.00	51.50	0.08
2	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	16,200	1,200	8	211.85	0.01	81.61	0.00	81.61	0.08
2	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	24,372	1,808	8	211.85	0.01	122.95	0.01	122.95	0.12
2	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	17,361	2,192	8	270.06	0.01	145.63	0.01	145.63	0.16
1	Articulated wheel loader, Cat988, 8.2 cy	Rubber Tired Loaders	475	Diesel	1,946	128	8	214.82	0.01	13.06	0.00	13.06	0.01
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	7,702	928	8	246.84	0.01	95.06	0.00	95.06	0.10
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,677	504	8	301.16	0.02	36.12	0.00	36.12	0.05
2	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,209	2,192	8	7623.11	0.11	32.09	0.00	32.09	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	2,565	1,096	8	7623.11	0.11	19.55	0.00	19.55	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	191	32	8	323.94	0.02	1.81	0.00	1.81	0.00
3	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	2,302	3,288	8	521.64	--	22.30	--	22.30	--
2	Engine generator, 10 KW	N/A - AP42 3.3-1	21	Gasoline	3,968	2,192	8	489.89	--	22.55	--	22.55	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,572	728	8	305.37	0.02	13.34	0.00	13.34	0.02
2	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	4,193	1,456	8	305.37	0.02	35.57	0.00	35.57	0.04
								Total		742.58	0.03	742.58	0.73
											Total CO2e	743.31	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N3E. Off-Road Construction Emissions for JC Boyle (Alternative 3)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	17,680	1,600	8	228.13	--	122.28	--	122.28	--
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	3,256	800	8	228.14	--	23.73	--	23.73	--
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Diesel	Diesel Excavators	321	9,612	712	8	316.47	--	72.33	--	72.33	--
2	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	51,332	3,808	8	316.47	--	386.85	--	386.85	--
1	Hydraulic excavator, 6 cy	Diesel	Diesel Excavators	513	11,014	488	8	316.47	--	79.23	--	79.23	--
2	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	11,912	1,504	8	316.46	--	117.09	--	117.09	--
5	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,300	1,000	8	316.48	--	131.34	--	131.34	--
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	9,280	1,000	8	316.48	--	75.32	--	75.32	--
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	3,072	1,600	8	10,177.90	--	31.27	--	31.27	--
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	3,744	1,600	8	10,177.90	--	38.11	--	38.11	--
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	12,582	2,104	8	316.49	--	116.53	--	116.53	--
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	1,495	2,136	8	521.64	--	14.48	--	14.48	--
1	Engine generator, 10 KW	Gasoline	N/A - AP42 3.3-1	21	3,446	1,904	8	489.89	--	19.59	--	19.59	--
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	2,888	1,072	8	351.37	--	22.60	--	22.60	--
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	3,087	1,072	8	351.37	--	30.13	--	30.13	--
								Total		1,280.87	0.00	1,280.87	0.00
											Total CO2e	1,280.87	

Global Warming Potential	
CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table N3F. Construction Worker Commute Emissions
Alternative 3 - Partial Facilities Removal

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	41	47	Oregon
Copco 1	56	78	California
Copco 2	38	69	California
Iron Gate	80	83	California

	Annual Emissions, metric tons/year (2020)			
Dam	**CO2**	**CH4**	**N2O**	
J.C. Boyle	27.10	n/a	n/a	
Copco 1	26.35	0.00	n/a	
Copco 2	59.72	0.00	n/a	
Iron Gate	35.85	0.00	n/a	
Total	149.03	0.01	0.00	
GWP	1	21	310	
Dam	**CO2e Emissions, MTCO2e/year**			
J.C. Boyle	27.10	n/a	n/a	
Copco 1	26.35	0.04	n/a	
Copco 2	59.72	0.08	n/a	
Iron Gate	35.85	0.05	n/a	
Total	149.03	0.17	0.00	
Total CO2e	**149.20**			
California Total	**122.09**			82%
Oregon Total	**27.10**			18%

Note:

Emission factors for N2O are not available in the EMFAC and MOBILE6 emission factor models.

Key:

CH4 = methane

CO2 = carbon dioxide

CO2e = carbon dioxide equivalent

GWP = global warming potential

MTCO2e/year = metric tons CO2e per year

n/a = not available

N2O = nitrous oxide

Table N3G. Annual Haul Truck Emissions
Alternative 3 - Partial Facilities Removal

		Annual	Round Trip	Annual Emissions (tons per year) - 2020			CO2e Emissions (MTCO2e/year			
Dam	**Waste Material**	**Trips**	**Distance (mi)**	**CO2**	**CH4**	**N2O**	**CO2**	**CH4**	**N2O**	**Total**
J.C. Boyle	Earth	8,500	1	11.86	n/a	n/a	12	n/a	n/a	12
	Concrete	1,300	3	5.44	n/a	n/a	5	n/a	n/a	5
	Metal	255	44	15.66	n/a	n/a	16	n/a	n/a	16
	J.C. Boyle Subtotal	10,055	48	32.96	0.00	0.00	33	0.00	0.00	33
Copco 1	Concrete	3,710	2	14.10	0.00	n/a	14	0.0041	n/a	14
(California)	Metal	65	62	7.66	0.00	n/a	8	0.0022	n/a	8
	Copco 1 Subtotal	3,775	64	21.75	0.00030	0.00	22	0.0063	0.00	22
Copco 2	Earth	0	2	0.00	0.00	n/a	0	0	n/a	0
(California)	Concrete	150	2	0.57	0.00	n/a	1	0.00017	n/a	1
	Metal	50	58	5.51	0.00	n/a	6	0.0016	n/a	6
	Wood-stave planks	45	240	20.52	0.00	n/a	21	0.0060	n/a	21
	Copco 2 Subtotal	245	302	26.60	0.00037	0.00	27	0.0077	0.00	27
Iron Gate	Earth	60,000	2	227.98	0.00	n/a	228	0.066	n/a	228
(California)	Concrete	500	2	1.90	0.00	n/a	2	0.00055	n/a	2
	Metal	75	54	7.69	0.00	n/a	8	0.0022	n/a	8
	Iron Gate Subtotal	60,575	58	237.58	0.0033	0.00	238	0.069	0.00	238
	Grand Total	**74,650**	**472**	**318.89**	**0.0040**	**0.00**	**319**	**0.08**	**0.00**	**319**
	California Total	**64,595**	**424**	**286**	**0.0040**	**0.00**	**286**	**0.08**	**0.00**	**286**
	Oregon Total	**10,055**	**48**	**33**	**0.00**	**0.00**	**33**	**0.00**	**0.00**	**33**
	California %	**87%**	**90%**	**90%**	**100%**	**0%**	**90%**	**100%**	**0%**	**90%**
	Oregon %	**13%**	**10%**	**10%**	**0%**	**0%**	**10%**	**0%**	**0%**	**10%**

Source: U.S. Department of the Interior, Bureau of Reclamation. 2011. Detailed Plan for Dam Removal - Klamath River Dams. Klamath Hydroelectric Project, FERC License No. 2082, Oregon - California. June 15.

Note:

Annual trips estimated from ratio of the quantity of waste disposed during Alternative 3 as compared to Alternative 2.

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
mi = miles
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

<u>Global Warming Potential</u>

CO2	1
CH4	21
N2O	310

Source:
IPCC 1996 - Second Assessment Report

Table N4A. Summary of Alternative 4 Off-Road Construction Emissions

		(metric tons)		CO2e (metric tons)		
Location	**Year**	**CO2**	**CH4**	**CO2**	**CH4**	**Total**
Iron Gate	2023	1,410.7	0.1	1,410.7	1.1	1,411.8
Copco 1	2024	1,158.5	0.0	1,158.5	0.8	1,159.4
Copco 2	2025	253.4	0.0	253.4	0.2	253.6
J.C. Boyle	2022	666.9	0.0	666.9	0.0	666.9
Maximum		1,410.7	0.1	1,410.7	1.1	1,411.8

Note:
Since construction emissions at each location happen during different years, emissions are not additive.
Maximum annual emissions used to evaluate significance.
Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent

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Table N4B. Off-Road Construction Emissions for Iron Gate Dam (Alternative 4)

Maximum Daily Work Hours 8 hours

							Peak Daily	2023 Emission Factors (g/hp-hr or g/gal for on-highway		2023 Emissions (metric tons per year)		2023 CO2e Emissions (metric tons per year)	
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	23,409	2,280	8	163.24	0.01	124.68	0.01	124.68	0.12
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Cranes	130	Diesel	13,936	3,424	8	208.07	0.01	92.61	0.01	92.61	0.11
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	7,668	568	8	211.85	0.01	38.63	0.00	38.63	0.03
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	23,078	1,712	8	211.85	0.01	116.42	0.00	116.42	0.10
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	13,559	1,712	8	270.06	0.01	113.74	0.00	113.74	0.10
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	18,990	2,288	8	246.84	0.01	234.38	0.01	234.38	0.21
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	5,271	568	8	301.16	0.02	40.71	0.00	40.71	0.05
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	191	Gasoline	8,276	2,280	8	6,642.21	0.42	54.97	0.00	54.97	0.07
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	4,378	2,280	8	7,623.11	0.11	33.37	0.00	33.37	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	5,335	2,280	8	7,623.11	0.11	40.67	0.00	40.67	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	6,841	1,144	8	323.94	0.02	64.85	0.00	64.85	0.07
5	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	36,975	4,560	8	230.44	0.01	246.94	0.01	246.94	0.16
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	1,335	568	8	280.06	0.01	21.95	0.00	21.95	0.02
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	1,439	2,056	8	521.64	--	13.94	--	13.94	--
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	576	4,112	8	489.89	--	5.54	--	5.54	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,227	568	8	275.84	0.01	9.40	0.00	9.40	0.01
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	1,636	568	8	275.84	0.01	12.53	0.00	12.53	0.01
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	14,415	1,144	8	10,080.00	0.11	145.30	0.00	145.30	0.03
								Total		1,410.65	0.05	1,410.65	1.13
											Total CO2e	1,411.78	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N4C. Off-Road Construction Equipment Emissions for Copco 1 (Alternative 4)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2025 Emission Factors (g/hp-hr or g/gal for on-highway)		2025 Emissions (metric tons per year)		2025 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	20,951	1,896	8	163.24	0.01	103.68	0.00	103.68	0.09
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Cranes	130	Diesel	11,591	2,848	8	208.07	0.01	77.03	0.00	77.03	0.08
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	6,372	472	8	211.85	0.01	32.10	0.00	32.10	0.02
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	19,196	1,424	8	211.85	0.01	96.84	0.00	96.84	0.07
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	11,278	1,424	8	270.06	0.01	94.60	0.00	94.60	0.08
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	7,902	952	8	246.84	0.01	97.52	0.00	97.52	0.08
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	4,380	472	8	301.16	0.02	33.83	0.00	33.83	0.04
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	191	Gasoline	6,882	1,896	8	6650.13	0.39	45.77	0.00	45.77	0.06
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	3,640	1,896	8	7623.11	0.10	27.75	0.00	27.75	0.01
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	4,437	1,896	8	7623.11	0.10	33.82	0.00	33.82	0.01
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	5,693	952	8	323.94	0.01	53.97	0.00	53.97	0.05
5	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	43,151	5,320	8	230.44	0.01	288.09	0.01	288.09	0.17
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	1,109	472	8	280.06	0.01	18.24	0.00	18.24	0.02
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	1,193	1,704	8	521.64	--	11.56	--	11.56	--
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	477	3,408	8	489.89	--	4.59	--	4.59	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	1,020	472	8	275.84	0.01	7.81	0.00	7.81	0.01
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	1,359	472	8	275.84	0.01	10.42	0.00	10.42	0.01
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	11,995	952	8	10080.00	0.10	120.91	0.00	120.91	0.02
									Total	1,158.54	0.04	1,158.54	0.82
											Total CO2e	1,159.36	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Global Warming Potential

CO2	1
CH4	21

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N4D. Off-Road Construction Emissions for Copco 2 (Alternative 4)

Maximum Daily Work Hours 8 hours

							Peak Daily	2024 Emission Factors (g/hp-hr or g/gal for on-highway		2024 Emissions (metric tons per year)		2024 CO2e Emissions (metric tons per year)	
Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Hours	CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	4,862	440	8	163.24	0.01	24.06	0.00	24.06	0.02
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	2,670	656	8	208.07	0.01	17.74	0.00	17.74	0.02
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	1,512	112	8	211.85	0.01	7.62	0.00	7.62	0.01
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	4,421	328	8	211.85	0.01	22.31	0.00	22.31	0.02
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	2,598	328	8	270.06	0.01	21.79	0.00	21.79	0.02
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	3,718	448	8	246.84	0.01	45.89	0.00	45.89	0.04
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	1,039	112	8	301.16	0.02	8.03	0.00	8.03	0.01
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	845	440	8	7623.12	0.10	6.44	0.00	6.44	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	1,030	440	8	7623.12	0.10	7.85	0.00	7.85	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	1,340	224	8	323.94	0.02	12.70	0.00	12.70	0.01
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	5,709	704	8	230.44	0.01	38.12	0.00	38.12	0.02
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	263	112	8	280.06	0.01	4.33	0.00	4.33	0.00
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	280	400	8	521.64	--	2.71	--	2.71	--
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	112	800	8	489.89	--	1.08	--	1.08	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	242	112	8	275.84	0.01	1.85	0.00	1.85	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	323	112	8	275.84	0.01	2.47	0.00	2.47	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	2,822	224	8	10080.01	0.10	28.45	0.00	28.45	0.01

	CO2	CH4	CO2	CH4
Total	253.44	0.01	253.44	0.19
Total CO2e			253.63	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
(blue shading) Onroad vehicle - emissions estimated by EMFAC2007
(green shading) Stationary source - emissions estimated by AP-42 for diesel engines

Table N4E. Off-Road Construction Emissions for JC Boyle (Alternative 4)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2022 Emission Factors (g/hp-hr or g/gal for on-highway		2022 Emissions (metric tons per year)		2022 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	10,696	968	8	228.15	--	73.98	--	73.98	--
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	5,926	1,456	8	228.16	--	43.19	--	43.19	--
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Diesel	Diesel Excavators	321	3,240	240	8	316.48	--	24.38	--	24.38	--
1	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	9,813	728	8	316.48	--	73.96	--	73.96	--
1	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	5,766	728	8	316.47	--	56.68	--	56.68	--
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,101	976	8	316.49	--	128.19	--	128.19	--
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	2,227	240	8	316.48	--	18.08	--	18.08	--
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	1,859	968	8	10177.90	--	18.92	--	18.92	--
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	2,265	968	8	10177.90	--	23.05	--	23.05	--
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	2,918	488	8	316.49	--	27.03	--	27.03	--
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Diesel	Diesel Cement & Mortar Mixers	235	12,455	1,536	8	228.03	--	82.31	--	82.31	--
1	Compactor, Cat, vibratory, self propelled, 84"	Diesel	Diesel Rollers	138	564	240	8	316.47	--	10.48	--	10.48	--
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	610	872	8	521.64	--	5.91	--	5.91	--
2	Portable generator 1 KW	Gasoline	N/A - AP42 3.3-2	2.75	244	1,744	8	489.89	--	2.35	--	2.35	--
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	647	240	8	351.42	--	5.06	--	5.06	--
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	691	240	8	351.42	--	6.75	--	6.75	--
1	Dump truck, on-highway 8x4, 18 cy	Diesel	N/A - MOBILE	450	6,149	488	8	10828.85	--	66.59	--	66.59	--
									Total	666.90	0.00	666.90	0.00
											Total CO2e	666.90	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table N4F. Construction Worker Commute Emissions
Alternative 4 - Fish Passage at Four Dams

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	20	179	Oregon
Copco 1	25	270	California
Copco 2	20	101	California
Iron Gate	30	344	California

		Annual Emissions, metric tons/year			
Dam	**Year**	**CO2**	**CH4**	**N2O**	**Total**
J.C. Boyle	2022	50	n/a	n/a	n/a
Copco 1	2025	63	0.0039	n/a	n/a
Copco 2	2024	19	0.0013	n/a	n/a
Iron Gate	2023	99	0.0071	n/a	n/a
Total		231	0.012	0.00	231
GWP		1	21	310	n/a
Dam	**Year**	**CO2e Emissions, MTCO2e/year**			
J.C. Boyle	2022	50	n/a	n/a	50
Copco 1	2025	63	0.083	n/a	63
Copco 2	2024	19	0.027	n/a	19
Iron Gate	2023	99	0.15	n/a	99
Total		231	0.15	0.00	231
Maximum		99	0.15	0.00	99

Note:
Emission factors for N2O are not available in the EMFAC and MOBILE6 emission factor models.
Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GWP = global warming potential
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Table N4G. Annual Haul Truck Emissions
Alternative 4 - Fish Passage at Four Dams

Dam	Waste Material	Annual Trips	Round Trip Distance (mi)	Annual Emissions (tons per year) CO2	CH4	N2O	CO2e Emissions (MTCO2e/year CO2	CH4	N2O	Total
J.C. Boyle 2022	Concrete	488	148	101	n/a	n/a	101	n/a	n/a	101
	Rebar	8	121	1	n/a	n/a	1	n/a	n/a	1
	Wood	4	121	1	n/a	n/a	1	n/a	n/a	1
	J.C. Boyle Subtotal	500	390	103	0.00	0.00	103	0.00	0.00	103
Copco 1 (California) 2024	Concrete	725	59	81	0.00081	n/a	81	0.017	n/a	81
	Rebar	13	120	3	0.000029	n/a	3	0.00062	n/a	3
	Wood	6	120	1	0.000014	n/a	1	0.00029	n/a	1
	Copco 1 Subtotal	744	299	85	0.00085	0.00	85	0.018	0.00	85
Copco 2 (California) 2025	Concrete	250	59	28	0.00026	n/a	28	0.0056	n/a	28
	Rebar	4	120	1	0.0000086	n/a	1	0.00018	n/a	1
	Wood	3	120	1	0.0000065	n/a	1	0.00014	n/a	1
	Copco 2 Subtotal	257	299	30	0.00028	0.00	30	0.0059	0.00	30
Iron Gate (California) 2023	Concrete	900	50	85	0.00091	n/a	85	0.019	n/a	85
	Rebar	16	90	3	0.000029	n/a	3	0.00061	n/a	3
	Wood	9	90	2	0.000016	n/a	2	0.00034	n/a	2
	Iron Gate Subtotal	925	230	90	0.0010	0.00	90	0.020	0.00	90
	Grand Total	**2,426**	**1,218**	**307**	**0.0021**	**0.00**	**307**	**0.044**	**0.00**	**307**
	Maximum	**925**	**390**	**103**	**0.0010**	**0**	**103**	**0.020**	**0**	**103**

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
mi = miles
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Global Warming Potential

CO2	1
CH4	21
N2O	310

Source:
IPCC 1996 - Second Assessment Report

Table N5A. Summary of Alternative 5 Off-Road Construction Emissions

	(metric tons)		CO2e (metric tons)		
	CO2	**CH4**	**CO2**	**CH4**	**Total**
Iron Gate	3,840.4	0.2	3,840.4	4.0	3,844.4
Copco 1	1,410.4	0.1	1,410.4	1.3	1,411.7
Copco 2	253.9	0.0	253.9	0.5	254.4
J.C. Boyle	666.9	0.0	666.9	0.0	666.9
Total	6,171.6	0.3	6,171.6	5.9	6,177.4
California %	89%	100%	89%	100%	89%
Oregon %	11%	0%	11%	0%	11%

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent

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Table N5B. Off-Road Construction Emissions for Iron Gate Dam (Alternative 5)

Maximum Daily Work Hours 14 hours

Dam Removal Duration
Start Date 6/1/2020
End Date 9/23/2020
83 days (5 days/week)
99 days (6 days/week)

Global Warming Potential
CO2 1
CH4 21

Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	2020 Emission Factors (g/hp-hr or g/gal for on-highway) CO2	2020 Emission Factors CH4	2020 Emissions (metric tons per year) CO2	2020 Emissions (metric tons per year) CH4	2020 CO2e Emissions (metric tons per year) CO2	2020 CO2e Emissions (metric tons per year) CH4
1	Crane - crawler, 150-200 ton	Cranes	335	Diesel	163.24	0.01	63.54	0.00	63.54	0.07
1	Crane - rough terrain hydraulic, 50 ton	Cranes	130	Diesel	208.07	0.02	31.43	0.00	31.43	0.05
4	Excavator - 180,000-240,000 lb, Hitachi ZX870 to EX1200	Excavators	646	Diesel	234.10	0.01	702.90	0.03	702.90	0.69
20	Dump truck - articulated, 35 ton, Cat 735	Off-Highway Trucks	435	Diesel	246.84	0.01	2,495.40	0.12	2,495.40	2.59
2	Dozer - D8	Rubber Tired Dozers	347	Diesel	240.08	0.02	193.60	0.02	193.60	0.32
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	191	Gasoline	6,624.02	0.50	18.47	0.00	18.47	0.03
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Onroad	160	Diesel	7,623.11	0.11	11.24	0.00	11.24	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Onroad	195	Diesel	7,623.11	0.11	13.70	0.00	13.70	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	323.94	0.02	65.87	0.00	65.87	0.08
1	Engine generator, 6.5 KW	N/A - Offroad diesel engine	13	Diesel	521.64	--	7.88	--	7.88	--
1	Engine generator, 10 KW	N/A - Offroad diesel engine	21	Gasoline	489.89	--	11.95	--	11.95	--
4	Submersible pump, 4" dia, 230 volt	Other Construction Equipment	175	Diesel	275.84	0.01	224.37	0.01	224.37	0.21
					Total		3,840.37	0.19	3,840.37	4.04
								Total CO2e	3,844.41	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N5C. Off-Road Construction Equipment Emissions for Copco 1 (Alternative 5)

Maximum Daily Work Hours 8

Dam Removal Duration
Start Date 12/30/2019
End Date 4/15/2020
78 (5 days/week)

Global Warming Potential
CO2 1
CH4 21

Quantity					2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
Primary	Secondary	Equipment Description	Rating (hp)	Fuel Type	CO2	CH4	CO2	CH4	CO2	CH4
1	1	Crane - crawler, 150-200 ton	335	Diesel	163.24	0.01	68.25	0.00	68.25	0.08
1	1	Crane - rough terrain hydraulic, 50 ton	130	Diesel	208.07	0.02	33.76	0.00	33.76	0.05
1	0	Excavator - hydraulic ram	321	Diesel	211.85	0.01	42.44	0.00	42.44	0.04
1	1	Excavator - 45,000-60,000 lb, Komatsu 220-350	219.5	Diesel	287.66	0.01	78.80	0.00	78.80	0.08
3	0	Excavator - <20,000 lb	168	Diesel	290.62	0.02	91.40	0.01	91.40	0.11
1	0	Loader - WA250 IT	138	Diesel	275.32	0.02	23.71	0.00	23.71	0.03
1	0	Loader - WA450	273	Diesel	214.82	0.01	36.60	0.00	36.60	0.04
2	0	Dump truck - articulated, 30 ton, Cat 730	325	Diesel	246.84	0.01	100.12	0.00	100.12	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Gasoline	6624.02	0.50	60.21	0.00	60.21	0.10
1	1	Pick-up truck, 1/2 ton, on-highway 4x4		Diesel	7623.11	0.11	36.65	0.00	36.65	0.01
1	1	Pick-up truck, 1 ton, on-highway 4x4		Diesel	7623.11	0.11	44.66	0.00	44.66	0.01
1	1	Pick-up truck, 3/4 ton, on-highway 4x4		Gasoline	6624.02	0.50	89.90	0.01	89.90	0.14
1	1	Water tanker, off-highway, 5000 gal	175	Diesel	323.94	0.02	70.75	0.00	70.75	0.09
1	1	Engine generator, 6.5 KW	13	Diesel	521.64	--	8.46	--	8.46	--
1	1	Engine generator, 10 KW	21	Gasoline	489.89	--	12.84	--	12.84	--
4	4	Air compressor, 850-1200 cfm	106	Diesel	305.37	0.02	161.59	0.01	161.59	0.19
4	4	Drills - air/hydraulic track, jackleg, or sinker	291	Diesel	282.17	0.01	409.89	0.01	409.89	0.20
2	2	Submersible pump, 4" dia, 230 volt	53	Diesel	305.37	0.02	40.40	0.00	40.40	0.05
					Total		1,410.41	0.06	1,410.41	1.32
								Total CO2e	1,411.73	

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N5D. Off-Road Construction Emissions for Copco 2 (Alternative 5)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	OFFROAD Category	Rating (hp)	Fuel Type	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per year)		2020 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Cranes	335	Diesel	4,862	440	8	163.24	0.01	24.06	0.00	24.06	0.03
2	Hydraulic yard crane, Grove 4x4x4, 13.6MT, 52' boom	Cranes	130	Diesel	2,670	656	8	208.07	0.02	17.74	0.00	17.74	0.03
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Excavators	321	Diesel	1,512	112	8	211.85	0.01	7.62	0.00	7.62	0.01
1	Hydraulic excavator, 2.5 cy	Excavators	321	Diesel	4,421	328	8	211.85	0.01	22.31	0.00	22.31	0.02
1	Articulated wheel loader, Cat966, 5.0 cy	Rubber Tired Loaders	246	Diesel	2,598	328	8	270.06	0.01	21.79	0.00	21.79	0.02
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Off-Highway Trucks	415	Diesel	3,718	448	8	246.84	0.01	45.89	0.00	45.89	0.05
1	Crawler dozer, Cat238	Crawler Tractors	238	Diesel	1,039	112	8	301.16	0.02	8.03	0.00	8.03	0.01
1	Pick-up truck, 1/2 ton, on-highway 4x4	N/A - Emfac	160	Diesel	845	440	8	7623.11	0.11	6.44	0.00	6.44	0.00
1	Pick-up truck, 1 ton, on-highway 4x4	N/A - Emfac	195	Diesel	1,030	440	8	7623.11	0.11	7.85	0.00	7.85	0.00
1	Water tanker, off-highway, 5000 gal	Off-Highway Trucks	175	Diesel	1,340	224	8	323.94	0.02	12.70	0.00	12.70	0.02
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Other Construction Equipment	235	Diesel	5,709	704	8	230.44	0.01	38.12	0.00	38.12	0.03
1	Compactor, Cat, vibratory, self propelled, 84"	Rollers	138	Diesel	263	112	8	280.06	0.02	4.33	0.00	4.33	0.01
1	Engine generator, 6.5 KW	N/A - AP42 3.3-1	13	Diesel	280	400	8	521.64	--	2.71	--	2.71	--
1	Air compressor, 160 cfm, 100 psi	Other Construction Equipment	60	Diesel	242	112	8	305.37	0.02	2.05	0.00	2.05	0.00
1	Air compressor, 250 cfm, 100 psi	Other Construction Equipment	80	Diesel	323	112	8	305.37	0.02	2.74	0.00	2.74	0.00
1	Dump truck, on-highway 8x4, 18 cy	N/A - Emfac	450	Diesel	2,822	224	8	10080.00	0.14	28.45	0.01	28.45	0.30
2	Portable generator 1 KW	N/A - AP42 3.3-1	2.75	Gasoline	112	800	8	489.89	--	1.08	--	1.08	--

	CO2	CH4	CO2	CH4
Total	253.91	0.02	253.91	0.52
		Total CO2e	254.43	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by EMFAC2007
Stationary source - emissions estimated by AP-42 for diesel engines

Table N5E. Off-Road Construction Emissions for JC Boyle (Alternative 5)

Maximum Daily Work Hours 8 hours

Quantity	Equipment Description	Fuel Type	NONROAD Category	Rating (hp)	Fuel Amount (gal)	Total Hours	Peak Daily Hours	2020 Emission Factors (g/hp-hr or g/gal for on-highway		2020 Emissions (metric tons per		2020 CO2e Emissions (metric tons per year)	
								CO2	CH4	CO2	CH4	CO2	CH4
1	Lattice boom crane, Manitowoc Crawler, 150T(US), 160'boom	Diesel	Diesel Cranes	335	10,696	968	8	228.13	--	73.98	--	73.98	--
2	Hydraulic yard crane, Grove 4x4x4, 52' boom, 13.6MT	Diesel	Diesel Cranes	130	5,926	1,456	8	228.14	--	43.18	--	43.18	--
1	Hydraulic excavator, 2.5 cy, long reach, Cat H120 Hoe Ram (3000 flb)	Diesel	Diesel Excavators	321	3,240	240	8	316.47	--	24.38	--	24.38	--
1	Hydraulic excavator, 2.5 cy	Diesel	Diesel Excavators	321	9,813	728	8	316.47	--	73.96	--	73.96	--
1	Articulated wheel loader, Cat966, 5.0 cy	Diesel	Diesel Rubber Tire Loaders	246	5,766	728	8	316.46	--	56.67	--	56.67	--
2	Dump truck, Cat740, 22.8-30 cy, 38.1 MT	Diesel	Diesel Off-highway Trucks	415	8,101	976	8	316.48	--	128.19	--	128.19	--
1	Crawler dozer, Cat238	Diesel	Diesel Crawler Tractors	238	2,227	240	8	316.48	--	18.08	--	18.08	--
1	Pick-up truck, 1/2 ton, on-highway 4x4	Diesel	N/A - MOBILE	160	1,859	968	8	10177.90	--	18.92	--	18.92	--
1	Pick-up trucks, 1 ton, on-highway 4x4	Diesel	N/A - MOBILE	195	2,265	968	8	10177.90	--	23.05	--	23.05	--
1	Water tanker, off-highway, 5000 gal	Diesel	Diesel Off-highway Trucks	175	2,918	488	8	316.49	--	27.03	--	27.03	--
4	Concrete Mixer, 8 cy, rear discharge/Concrete pump truck	Diesel	Diesel Cement & Mortar Mixers	235	12,455	1,536	8	228.00	--	82.30	--	82.30	--
1	Compactor, Cat, vibratory, self propelled, 84"	Diesel	Diesel Rollers	138	564	240	8	316.45	--	10.48	--	10.48	--
1	Engine generator, 6.5 KW	Diesel	N/A - AP42 3.3-1	13	610	872	8	521.64	--	5.91	--	5.91	--
1	Air compressor, 160 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	60	647	240	8	351.37	--	5.06	--	5.06	--
1	Air compressor, 250 cfm, 100 psi	Diesel	Diesel Other Construction Equipment	80	691	240	8	351.37	--	6.75	--	6.75	--
1	Dump truck, on-highway 8x4, 18 cy	Diesel	N/A - MOBILE	450	6,149	488	8	10828.85	--	66.59	--	66.59	--
2	Portable generator 1 KW	Gasoline	N/A - AP42 3.3-1	2.75	244	1,744	8	489.89	--	2.35	--	2.35	--
									Total	666.88	0.00	666.88	0.00
											Total CO2e	666.88	

Global Warming Potential

CO2	1
CH4	21

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
g/gal = grams per gallon
g/hp-hr = grams per horsepower-hour

Legend
Onroad vehicle - emissions estimated by MOBILE6.2
Stationary source - emissions estimated by AP-42 for diesel engines

Table N5F. Construction Worker Commute Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Round-Trip Commute Distance: 30 miles

Dam	Peak Workers	Duration (Days)	State
J.C. Boyle	17	47	Oregon
Copco 1	56	78	California
Copco 2	15	69	California
Iron Gate	80	83	California

	Annual Emissions, metric tons/year (2020)			
Dam	CO2	CH4	N2O	
J.C. Boyle	11.24	n/a	n/a	
Copco 1	59.72	0.00	n/a	
Copco 2	14.15	0.00	n/a	
Iron Gate	90.79	0.01	n/a	
Total	175.90	0.01	0.00	
GWP	1	21	310	
Dam	**CO2e Emissions, MTCO2e/year**			
J.C. Boyle	11.24	n/a	n/a	
Copco 1	59.72	0.08	n/a	
Copco 2	14.15	0.02	n/a	
Iron Gate	90.79	0.13	n/a	
Total	175.90	0.23	0.00	
Total CO2e	**176.13**			
California Total	**164.90**			94%
Oregon Total	**11.24**			6%

Note:
Emission factors for N2O are not available in the EMFAC and MOBILE6 emission factor models.

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
GWP = global warming potential
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Table N5G. Annual Haul Truck Emissions
Alternative 5 - Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Dam	Waste Material	Annual Trips	Round Trip Distance (mi)	Annual Emissions (tons per year) - 2020			CO2e Emissions (MTCO2e/year			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
J.C. Boyle	Concrete (In)	350	148	72.29	n/a	n/a	72	n/a	n/a	72
	Rebar	6	121	1.01	n/a	n/a	1	n/a	n/a	1
	Wood	3	121	0.51	n/a	n/a	1	n/a	n/a	1
	J.C. Boyle Subtotal	359	390	73.81	0.00	0.00	74	0.00	0.00	74
Copco 1 (California)	Concrete (Out)	4,000	2	15.20	0.00	n/a	15	0.0044	n/a	15
	Metal	170	62	20.02	0.00	n/a	20	0.0058	n/a	20
	Building Waste	30	62	3.53	0.00	n/a	4	0.0010	n/a	4
	Copco 1 Subtotal	4,200	126	38.76	0.00	0.00	39	0.011	0.00	39
Copco 2 (California)	Concrete (In)	125	59	14.01	0.00	n/a	14	0.0041	n/a	14
	Rebar	2	120	0.46	0.00	n/a	0	0.00013	n/a	0
	Wood	2	120	0.46	0.00	n/a	0	0.00013	n/a	0
	Copco 2 Subtotal	129	299	14.92	0.00021	0.00	15	0.0043	0.00	15
Iron Gate (California)	Earth	60,000	2	227.98	0.00	n/a	228	0.066	n/a	228
	Concrete (Out)	750	2	2.85	0.00	n/a	3	0.00083	n/a	3
	Metal	130	54	13.34	0.00	n/a	13	0.00388	n/a	13
	Building Waste	40	54	4.10	0.00	n/a	4	0.00119	n/a	4
	Iron Gate Subtotal	60,920	112	248.27	0.00	0.00	248	0.072	0.00	248
	Grand Total	**65,608**	**927**	**375.76**	**0.0042**	**0.00**	**376**	**0.09**	**0.00**	**376**
	California Total	**65,249**	**537**	**302**	**0.0042**	**0.00**	**302**	**0.09**	**0.00**	**302**
	Oregon Total	**359**	**390**	**74**	**0.00**	**0.00**	**74**	**0.00**	**0.00**	**74**
	California %	**99%**	**58%**	**80%**	**100%**	**0%**	**80%**	**100%**	**0%**	**80%**
	Oregon %	**1%**	**42%**	**20%**	**0%**	**0%**	**20%**	**0%**	**0%**	**20%**

Key:
CH4 = methane
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
mi = miles
MTCO2e/year = metric tons CO2e per year
n/a = not available
N2O = nitrous oxide

Global Warming Potential

CO2	1
CH4	21
N2O	310

Source:
IPCC 1996 - Second Assessment Report

Table N6A. Generation Resource Mix for Electricity Emissions

NWPP

Nonrenewable Resource	**Fuel Mix %**	**MWh**
Coal	32.0%	86,260,263.9
Oil	0.2%	602,465.1
Gas	12.8%	34,485,140.6
Other Fossil	0.3%	778,321.0
Nuclear	3.0%	8,108,560.0
Other Unknown / Purchased Fuel	0.1%	137,632.7
Nonrenewable Total	48.3%	130,372,383.4
Grand Total	**100.0%**	**269,912,352.3**

Renewable Resource	**Fuel Mix %**	**MWh**
Wind	1.9%	5,090,845.3
Solar	0.0%	0.0
Geothermal	0.3%	925,122.0
Biomass	1.1%	2,979,437.1
Hydro	48.4%	130,544,564.6
Renewable Total	51.7%	139,539,969.0
Nonhydro Renewable Total	3.3%	8,995,404.4

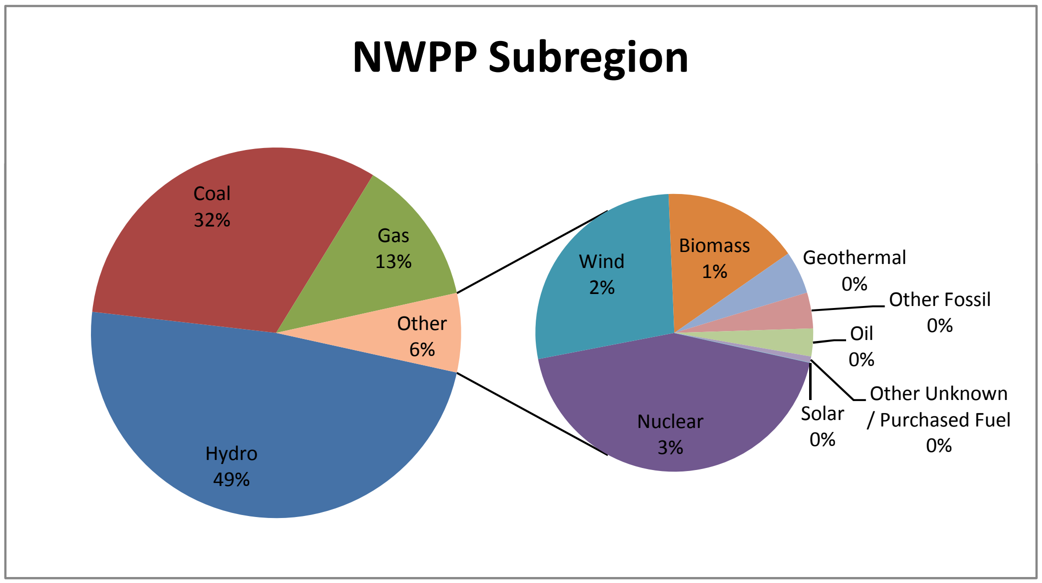

Table N6A. Generation Resource Mix for Electricity Emissions (continued)

PacifiCorp

Nonrenewable Resource	**Fuel Mix %**	**MWh**
Coal	76.3%	51,841,990.6
Oil	0.1%	65,065.4
Gas	14.3%	9,689,122.8
Other Fossil	0.5%	317,120.2
Nuclear	0.0%	0.0
Other Unknown / Purchased Fuel	0.1%	69,033.7
Nonrenewable Total	91.2%	61,982,332.8
Grand Total	**100.0%**	**67,961,659.9**

Renewable Resource	**Fuel Mix %**	**MWh**
Wind	1.7%	1,164,651.0
Solar	0.0%	0.0
Geothermal	0.2%	163,925.0
Biomass	0.8%	521,601.6
Hydro	6.1%	4,129,149.6
Renewable Total	8.8%	5,979,327.2
Nonhydro Renewable Total	2.7%	1,850,177.6

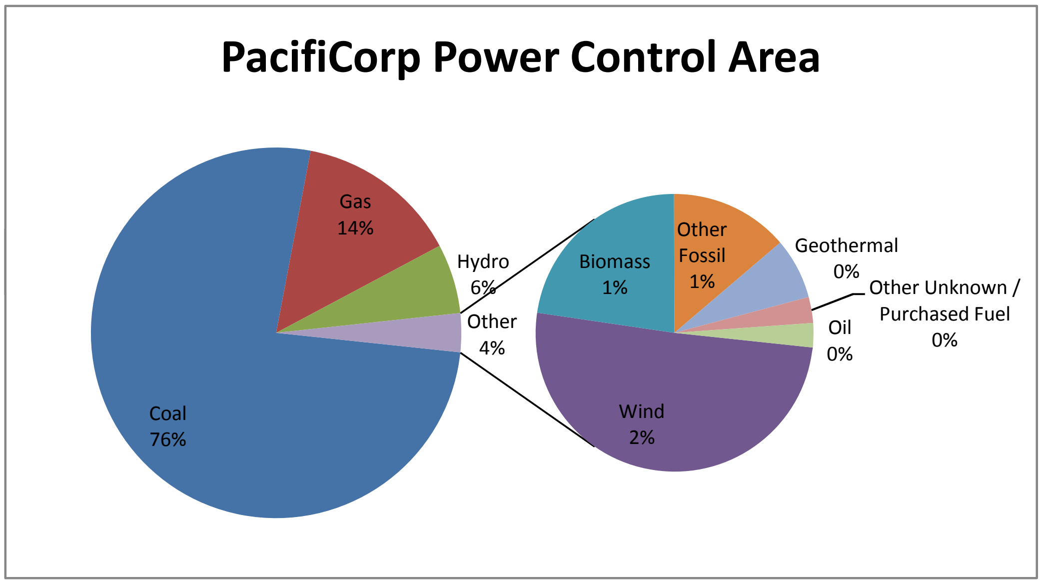

Table N6B. Electricity Emissions Profile - Base Load (Off-Peak)

PacifiCorp

Capacity (MW):	12,171.2
Net Generation (MWh):	67,961,659.9
Heat Input (MMBtu):	646,819,058.7

Annual Emissions

Pollutant	Emissions	Units
CO2	62,507,461.8	tons
CH4	1,790,449.1	lbs
N2O	2,040,423.8	lbs

Output Emission Rates

Pollutant	Emission Rate	Units
CO2	1,839.49	lb/MWh
CH4	26.34	lb/GWh
N2O	30.02	lb/GWh

Dam	Generation (MWh)	Capacity (MW)
Iron Gate	119,206.0	18.0
Copco 1	95,316.0	20.0
Copco 2	119,854.0	27.0
John C Boyle	279,767.0	98.7
Total	614,143.0	163.7

Natural Gas

Capacity (MW):	437,528.6
Net Generation (MWh):	894,494,854.6
Heat Input (MMBtu):	7,049,211,251.1

Annual Emissions

Pollutant	Emissions	Units
CO2	422,039,953.7	tons
CH4	17,230,682.8	lbs
N2O	1,829,313.3	lbs

Output Emission Rates

Pollutant	Emission Rate	Units
CO2	943.64	lb/MWh
CH4	38.53	lb/GWh
N2O	4.09	lb/GWh

Adjusted Emissions - Iron Gate, Copco 1, Copco 2, and Iron Gate Removed

Net Generation (MWh): 67,347,516.9

Pollutant	Emission Rate	Units
CO2	1,856.27	lb/MWh
CH4	26.59	lb/GWh
N2O	30.30	lb/GWh

Adjusted Emissions - Iron Gate and Copco 1 Removed

Net Generation (MWh): 67,747,137.9

Pollutant	Emission Rate	Units
CO2	1,845.32	lb/MWh
CH4	26.43	lb/GWh
N2O	30.12	lb/GWh

Table N6C. Potential Emissions from Power Replacement (Alternatives 2 and 3)

	Annual Total Output Emisson Rates Base Load (Off-Peak)			
Alt	CO2 (lb/MWh)	CH4 (lb/GWh)	N2O (lb/GWh)	
Off-Peak	1,856.27	26.59	30.30	(PacifiCorp PCA Resource Mix)
On-Peak	943.64	38.53	4.09	(Natural Gas)
33% RPS	1,363.68	19.53	22.26	

Iron Gate and Copco 1 Removed

Peaking Power (Natural Gas)

Pollutant	State	Generation (MWh)	Annual Emissions (metric ton/year) CO2	CH4	N2O	Annual CO2e Emissions (MTCO2e/yr) CO2	CH4	N2O	Total
Iron Gate	California	74,571	31,919	1.3	0.1	31,919	27	43	31,989
Copco 1	California	68,143	29,167	1.2	0.1	29,167	25	39	29,232
Copco 2	California	86,786	37,147	1.5	0.2	37,147	32	50	37,229
JC Boyle	Oregon	211,500	90,529	3.7	0.4	90,529	78	122	90,729
Total		441,000	188,763	7.7	0.8	188,763	162	254	189,179
Total California		229,500	98,234	4.0	0.4	98,234	84	132	98,450
Total Oregon		211,500	90,529	3.7	0.4	90,529	78	122	90,729

Generation based on FERC EIS (Table 4-8), Average Annual Generation (MWh)

Off-Peak (PacifiCorp PCA Resource Mix)

Pollutant	State	Generation (MWh)	Annual Emissions (metric ton/year) CO2	CH4	N2O	Annual CO2e Emissions (MTCO2e/yr) CO2	CH4	N2O	Total
Iron Gate	California	41,429	34,883	0.5	0.6	34,883	10	176	35,070
Copco 1	California	37,857	31,876	0.5	0.5	31,876	10	161	32,047
Copco 2	California	48,214	40,597	0.6	0.7	40,597	12	205	40,814
JC Boyle	Oregon	117,500	98,935	1.4	1.6	98,935	30	501	99,466
Total		245,000	206,291	3.0	3.4	206,291	62	1,044	207,396
Total California		127,500	107,355	1.5	1.8	107,355	32	543	107,931
Total Oregon		117,500	98,935	1.4	1.6	98,935	30	501	99,466

Generation based on FERC EIS (Table 4-8), Average Annual Generation (MWh)

Total Emissions (Existing Grid)

Pollutant	State	Generation (MWh)	Annual Emissions (metric ton/year) CO2	CH4	N2O	Annual CO2e Emissions (MTCO2e/yr) CO2	CH4	N2O	Total
Iron Gate	California	116,000	66,802	1.8	0.7	66,802	38	219	67,059
Copco 1	California	106,000	61,043	1.6	0.6	61,043	35	200	61,278
Copco 2	California	135,000	77,744	2.1	0.8	77,744	44	255	78,043
JC Boyle	Oregon	329,000	189,465	5.1	2.0	189,465	107	622	190,194
Total		686,000	395,054	10.7	4.2	395,054	224	1,297	396,575
Total California		357,000	205,589	5.5	2.2	205,589	117	675	206,381
Total Oregon		329,000	189,465	5.1	2.0	189,465	107	622	190,194

Generation based on FERC EIS (Table 4-8), Average Annual Generation (MWh)

Table N6C. Potential Emissions from Power Replacement (Alternatives 2 and 3) (continued)

Off-Peak (33% RPS)

Pollutant	State	Generation (MWh)	Annual Emissions (metric ton/year)			Annual CO2e Emissions (MTCO2e/yr)			
			CO2	CH4	N2O	CO2	CH4	N2O	Total
Iron Gate	California	41,429	25,626	0.4	0.4	25,626	8	130	25,764
Copco 1	California	37,857	23,417	0.3	0.4	23,417	7	118	23,543
Copco 2	California	48,214	29,824	0.4	0.5	29,824	9	151	29,983
JC Boyle	Oregon	117,500	72,681	1.0	1.2	72,681	22	368	73,071
Total		245,000	151,548	2.2	2.5	151,548	46	767	152,360
Total California		127,500	78,867	1.1	1.3	78,867	24	399	79,290
Total Oregon		117,500	72,681	1.0	1.2	72,681	22	368	73,071

Generation based on FERC EIS (Table 4-8), Average Annual Generation (MWh)

Total Emissions (33% RPS)

Pollutant	State	Generation (MWh)	Annual Emissions (metric ton/year)			Annual CO2e Emissions (MTCO2e/yr)			
			CO2	CH4	N2O	CO2	CH4	N2O	Total
Iron Gate	California	116,000	57,545	1.7	0.6	57,545	35	173	57,753
Copco 1	California	106,000	52,585	1.5	0.5	52,585	32	158	52,774
Copco 2	California	135,000	66,971	1.9	0.6	66,971	41	201	67,212
JC Boyle	Oregon	329,000	163,210	4.7	1.6	163,210	99	489	163,799
Total		686,000	340,311	9.9	3.3	340,311	207	1,020	341,539
Total California		357,000	177,101	5.1	1.7	177,101	108	531	177,740
Total Oregon		329,000	163,210	4.7	1.6	163,210	99	489	163,799

Generation based on FERC EIS (Table 4-8), Average Annual Generation (MWh)

GWP	
CO2	1
CH4	21
N2O	310

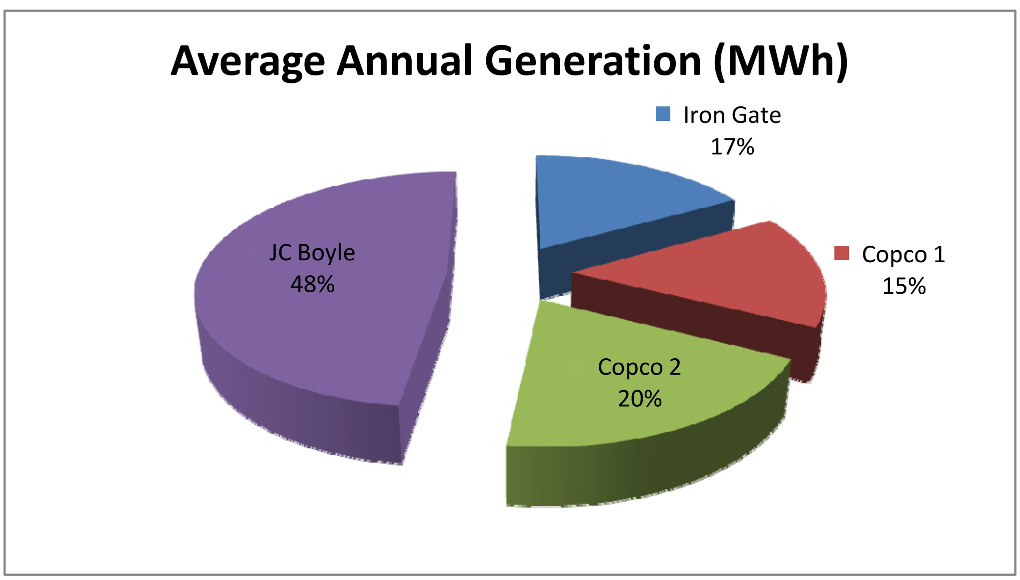

Table N6D. Potential Emissions from Power Replacement (Alternative 4)

	Annual Total Output Emisson Rates Base Load (Off-Peak)			
Alt	CO_2 (lb/MWh)	CH_4 (lb/GWh)	N_2O (lb/GWh)	
Off-Peak	1,839.49	26.34	30.02	(PacifiCorp PCA Resource Mix)
On-Peak	943.64	38.53	4.09	(Natural Gas)
33% RPS	1,351.35	19.35	22.06	

Fish Passage Alternative

Baseline (all dams)	686,000 MWh	(Includes Iron Gate, Copco, and JC Boyle)
Average Annual Electricity Generation	533,879 MWh	(FERC EIS, Section 4.4)
Difference	152,121 MWh	

Total Emissions (Existing Grid)

Pollutant	Generation (MWh)	Annual Emissions (metric ton/year)			Annual CO2e Emissions (MTCO2e/yr)			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	1.7	0.2	41,858	36	56	41,951
Off-Peak	54,329	45,332	0.6	0.7	45,332	14	229	45,575
Total	152,121	87,190	2.4	0.9	87,190	50	286	87,525

Total Emissions (33% RPS)

Pollutant	Generation (MWh)	Annual Emissions (metric ton/year)			Annual CO2e Emissions (MTCO2e/yr)			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	1.7	0.2	41,858	36	56	41,951
Off-Peak	54,329	33,302	0.5	0.5	33,302	10	168	33,481
Total	152,121	75,161	2.2	0.7	75,161	46	225	75,431

GWP

CO_2	1
CH_4	21
N_2O	310

Table N6E. Potential Emissions from Power Replacement (Alternative 5)

Alt	Annual Total Output Emisson Rates Base Load (Off-Peak) CO2 (lb/MWh)	CH4 (lb/GWh)	N2O (lb/GWh)	
Off-Peak	1,845.32	26.43	30.12	(PacifiCorp PCA Resource Mix)
On-Peak	943.64	38.53	4.09	(Natural Gas)
33% RPS	1,355.63	19.42	22.13	

Fish Passage Alternative

Baseline (all dams)	686,000	MWh	(Includes Iron Gate, Copco, and JC Boyle)
Average Annual Electricity Generation	443,694	MWh	(FERC EIS, Section 4.4)
Difference	242,306	MWh	

Total Emissions (Existing Grid)

Pollutant	Generation (MWh)	Annual Emissions (metric ton/year) CO2	CH4	N2O	Annual CO2e Emissions (MTCO2e/yr) CO2	CH4	N2O	Total
On-Peak	155,768	66,674	2.7	0.3	66,674	57	90	66,821
Off-Peak	86,538	72,435	1.0	1.2	72,435	22	366	72,824
Total	242,306	139,109	3.8	1.5	139,109	79	456	139,644

Total Emissions (33% RPS)

Pollutant	Generation (MWh)	Annual Emissions (metric ton/year) CO2	CH4	N2O	Annual CO2e Emissions (MTCO2e/yr) CO2	CH4	N2O	Total
On-Peak	155,768	66,674	2.7	0.3	66,674	57	90	66,821
Off-Peak	86,538	53,213	0.8	0.9	53,213	16	269	53,499
Total	242,306	119,888	3.5	1.2	119,888	73	359	120,320

GWP	
CO2	1
CH4	21
N2O	310

Table N7A. Power Replacement Impact Summary Table (With Methane Generation from Reservoirs)

Alternative	Power Replacement and CH4 from Impounded Reservoirs Emissions (MTCO2e/yr)			
	Current Resource Mix		33 Percent RPS	
	Low	High	Low	High
2	392,575	382,575	337,539	327,539
3	392,575	382,575	337,539	327,539
4	91,525	101,525	79,431	89,431
5	140,344	142,644	121,020	123,320

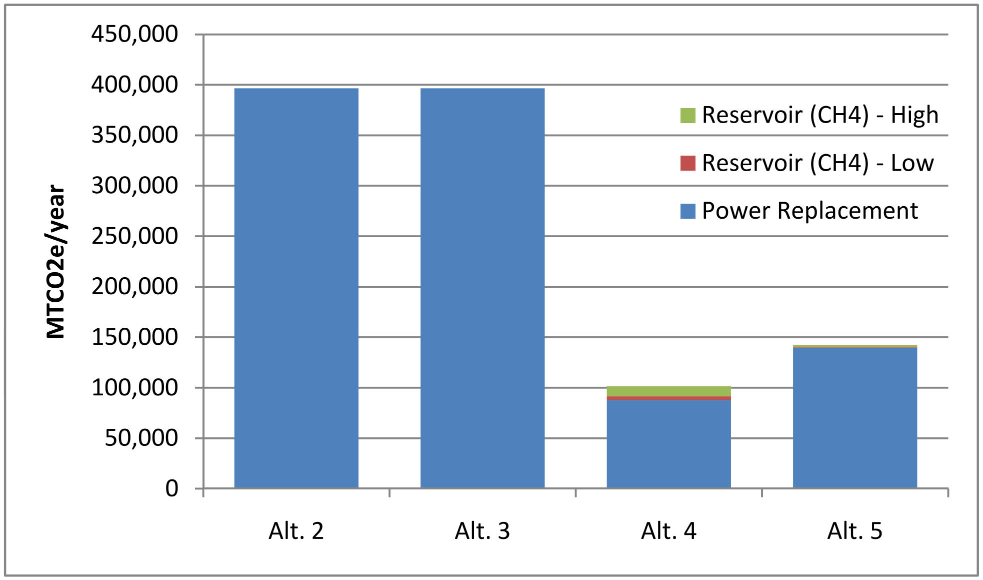

Table N7B. Estimated Methane Emissions from All Reservoirs

KHP Reservoir Area[1]	CH_4 Flux		CH_4 Mass Flow Rate[4]	CH_4 Mass Flow Rate[5]	GWP per Year[6]	KHP CO_2 Displacement[7]	GWP of CH_4 Emissions as % of Displacement[8]
(m^2)	Source	(mg CH_4/m^2d)	(MT CH_4/d)	(MT CH_4/yr)	(MT CO_2e/yr)	(MT CO_2/yr)	(%)
19,582,738	Lake Shasta[2]	11	0.215	79	1,651	265,455	0.62%
19,582,738	Lake Mendota[3]	50	0.979	357	7,505	265,455	2.83%
19,582,738		100	1.958	715	15,010	265,455	5.65%
19,582,738	Priest Pot[3]	193	3.779	1,380	28,970	265,455	10.91%
19,582,738	Flooded Rainforest Reservoir[2]	500	9.791	3,574	75,051	265,455	28.27%

Notes:

[1]Area (m^2) = Keno + JC Boyle + Copco + Iron Gate = 2475 + 420 + 1000 + 944 = 4389 acres, unit conversion to m^2 = 19582738

[2]Source: Soumis et al. (2004)

[3]Source: Bastviken et a. (2004)

[4]CH_4 mass flow rate (MT CH_4/d) = (CH_4 flux)*(Area)

[5]CH4 mass flow rate (MT CH_4/yr) = (CH_4 mass flow rate)*(365 d/yr)

[6]GWP per year (MT CO_2e/yr) = (CH_4 mass flow rate)*(23) because CH_4 is 23 times more potent than CO_2 on a mass basis (IPCC 2001)

[7]KHP Carbon Displacement = Amount of carbon that would be released annually from a natural gas power plant that would replace KHP generation.
(101 kg C/MWh)*(KHP generation 716,800 MWh/yr)*(3.66666666666667 kg CO2/kg C)/(unit conversion 1000 kg/MT) [Source: FERC DEIS and Table 3]

[8]GWP of CH_4 Emissions as % of Displacement = (GWP per year)/(KHP Carbon Displacement)

Table Source:
Karuk Tribe of California. 2006. Comments on Draft EIS in Klamath Hydroelectric Project Docket for Filing: P-2082-027 (Klamath). Submitted to FERC by the Karuk Tribe of California, Orleans, CA. 60 p.
Available online at: <http://www.klamathwaterquality.com/documents/karuk_comments_20061201-5040(16445270).pdf>

Replacement Power Estimate (Current Grid)	396,575	MTCO2e/year
Range of Replaced Power	2% to 7%	
Replacement Power Estimate (33% RPS)	341,539	MTCO2e/year
Range of Replaced Power	2% to 8%	

Reservoir	Area (acres)
Keno	2,475
JC Boyle	420
Copco	1,000
Iron Gate	944
Total	4,839

CH_4 GWP 21

Table N7C. Estimated Methane Emissions from All Reservoirs Excluding Keno

KHP Reservoir Area[1]	CH_4 Flux		CH_4 Mass Flow Rate[4]	CH_4 Mass Flow Rate[5]	GWP per Year[6]	KHP CO_2 Displacement[7]	GWP of CH_4 Emissions as % of Displacement[8]
(m^2)	Source	(mg CH_4/m^2d)	(MT CH_4/d)	(MT CH_4/yr)	(MT CO_2e/yr)	(MT CO_2/yr)	(%)
9,566,769	Lake Shasta[2]	11	0.105	38	807	265,455	0.30%
9,566,769	Lake Mendota[3]	50	0.478	175	3,666	265,455	1.38%
9,566,769		100	0.957	349	7,333	265,455	2.76%
9,566,769	Priest Pot[3]	193	1.846	674	14,153	265,455	5.33%
9,566,769	Flooded Rainforest Reservoir[2]	500	4.783	1,746	36,665	265,455	13.81%

Notes:

[1]Area (m^2) = Keno + JC Boyle + Copco + Iron Gate = 2475 + 420 + 1000 + 944 = 4389 acres, unit conversion to m^2 = 19582738

[2]Source: Soumis et al. (2004)

[3]Source: Bastviken et a. (2004)

[4]CH_4 mass flow rate (MT CH_4/d) = (CH_4 flux)*(Area)

[5]CH4 mass flow rate (MT CH_4/yr) = (CH_4 mass flow rate)*(365 d/yr)

[6]GWP per year (MT CO_2e/yr) = (CH_4 mass flow rate)*(23) because CH_4 is 23 times more potent than CO_2 on a mass basis (IPCC 2001)

[7]KHP Carbon Displacement = Amount of carbon that would be released annually from a natural gas power plant that would replace KHP generation.
(101 kg C/MWh)*(KHP generation 716,800 MWh/yr)*(3.66666666666667 kg CO2/kg C)/(unit conversion 1000 kg/MT) [Source: FERC DEIS and Table 3]

[8]GWP of CH_4 Emissions as % of Displacement = (GWP per year)/(KHP Carbon Displacement)

Table Source:
Karuk Tribe of California. 2006. Comments on Draft EIS in Klamath Hydroelectric Project Docket for Filing: P-2082-027 (Klamath). Submitted to FERC by the Karuk Tribe of California, Orleans, CA. 60 p.
Available online at: <http://www.klamathwaterquality.com/documents/karuk_comments_20061201-5040(16445270).pdf>

Replacement Power Estimate (Current Grid)	396,575	MTCO2e/year
Range of Replaced Power	1% to 4%	
Replacement Power Estimate (Current Grid)	341,539	MTCO2e/year
Range of Replaced Power	1% to 4%	

Table N7C. Estimated Methane Emissions from All Reservoirs Excluding Keno (continued)

Adjusted Power Replacement Emissions Without Methane Emissions from Reservoirs

Scenario	Annual CO2e Emissions (MTCO2e/year)	CH4 Emissions from Reservoirs (MTCO2e/year)		Adjusted Emissions (MTCO2e/year)	
		Low	High	Low	High
Alternative 2 and 3					
Current Grid	396,575	4,000	14,000	392,575	382,575
33% RPS	341,539	4,000	14,000	337,539	327,539
Alternative 4					
Current Grid	87,525	4,000	14,000	91,525	101,525
33% RPS	75,431	4,000	14,000	79,431	89,431

Reservoir	Area (acres)
Keno	--
JC Boyle	420
Copco	1,000
Iron Gate	944
Total	2,364

CH_4 GWP 21

Table N7D. Estimated Methane Emissions from JC Boyle Reservoir

KHP Reservoir Area[1]	CH_4 Flux		CH_4 Mass Flow Rate[4]	CH_4 Mass Flow Rate[5]	GWP per Year[6]	KHP CO_2 Displacement[7]	GWP of CH_4 Emissions as % of Displacement[8]
(m^2)	Source	(mg CH_4/m^2d)	(MT CH_4/d)	(MT CH_4/yr)	(MT CO_2e/yr)	(MT CO_2/yr)	(%)
1,699,680	Lake Shasta[2]	11	0.019	7	143	265,455	0.05%
1,699,680	Lake Mendota[3]	50	0.085	31	651	265,455	0.25%
1,699,680		100	0.170	62	1,303	265,455	0.49%
1,699,680	Priest Pot[3]	193	0.328	120	2,514	265,455	0.95%
1,699,680	Flooded Rainforest Reservoir[2]	500	0.850	310	6,514	265,455	2.45%

Notes:

[1]Area (m^2) = Keno + JC Boyle + Copco + Iron Gate = 2475 + 420 + 1000 + 944 = 4389 acres, unit conversion to m^2 = 19582738

[2]Source: Soumis et al. (2004)

[3]Source: Bastviken et a. (2004)

[4]CH_4 mass flow rate (MT CH_4/d) = (CH_4 flux)*(Area)

[5]CH4 mass flow rate (MT CH_4/yr) = (CH_4 mass flow rate)*(365 d/yr)

[6]GWP per year (MT CO_2e/yr) = (CH_4 mass flow rate)*(23) because CH_4 is 23 times more potent than CO_2 on a mass basis (IPCC 2001)

[7]KHP Carbon Displacement = Amount of carbon that would be released annually from a natural gas power plant that would replace KHP generation.
(101 kg C/MWh)*(KHP generation 716,800 MWh/yr)*(3.66666666666667 kg CO2/kg C)/(unit conversion 1000 kg/MT) [Source: FERC DEIS and Table 3]

[8]GWP of CH_4 Emissions as % of Displacement = (GWP per year)/(KHP Carbon Displacement)

Table Source:
Karuk Tribe of California. 2006. Comments on Draft EIS in Klamath Hydroelectric Project Docket for Filing: P-2082-027 (Klamath). Submitted to FERC by the Karuk Tribe of California, Orleans, CA. 60 p.
Available online at: <http://www.klamathwaterquality.com/documents/karuk_comments_20061201-5040(16445270).pdf>

Replacement Power Estimate (Current Grid)	139,644	MTCO2e/year
Range of Replaced Power	0.5% to 2%	
Replacement Power Estimate (Current Grid)	120,320	MTCO2e/year
Range of Replaced Power	0.5% to 2%	

Table N7D. Estimated Methane Emissions from JC Boyle Reservoir (continued)

Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs

Scenario	Annual CO2e Emissions (MTCO2e/year)	CH4 Emissions from Reservoirs (MTCO2e/year)		Adjusted Emissions (MTCO2e/year)	
		Low	High	Low	High
Alternative 5					
Current Grid	139,644	700	3,000	140,344	142,644
33% RPS	120,320	700	3,000	121,020	123,320

Reservoir	Area (acres)
Keno	--
JC Boyle	420
Copco	--
Iron Gate	--
Total	420

CH_4 GWP 21

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Table N8A. Summary of EMFAC2007 Emission Factors

Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Emission Factors (g/mi) - 2019															
Construction Workers	0.551	0.588	4.680	0.487	0.004	0.041	0.021	0.008	0.013	0.027	0.019	0.002	0.005	351.872	0.033
Pick-up Trucks (Gasoline)	0.442	0.476	3.714	0.465	0.005	0.052	0.031	0.008	0.013	0.037	0.029	0.002	0.005	503.354	0.031
Pick-up Trucks (Diesel)	0.082	0.094	0.638	1.477	0.003	0.074	0.053	0.008	0.013	0.056	0.049	0.002	0.005	346.620	0.004
Heavy-Duty Diesel Trucks	0.628	0.715	2.737	7.691	0.018	0.317	0.253	0.036	0.028	0.254	0.233	0.009	0.012	1901.576	0.029
Source	**Emission Factors (g/mi) - 2020**														
Construction Workers	0.506	0.539	4.201	0.439	0.004	0.041	0.021	0.008	0.013	0.026	0.019	0.002	0.005	337.274	0.030
Pick-up Trucks (Gasoline)	0.413	0.444	3.396	0.423	0.005	0.052	0.031	0.008	0.013	0.037	0.029	0.002	0.005	503.380	0.029
Pick-up Trucks (Diesel)	0.081	0.092	0.630	1.482	0.003	0.073	0.052	0.008	0.013	0.055	0.048	0.002	0.005	346.726	0.004
Heavy-Duty Diesel Trucks	0.566	0.645	2.498	6.793	0.018	0.283	0.219	0.036	0.028	0.223	0.202	0.009	0.012	1899.853	0.026
Source	**Emission Factors (g/mi) - 2023**														
Construction Workers	0.387	0.412	2.867	0.312	0.004	0.040	0.020	0.008	0.013	0.026	0.018	0.002	0.005	319.237	0.023
Pick-up Trucks (Gasoline)	0.344	0.370	2.600	0.319	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.455	0.024
Pick-up Trucks (Diesel)	0.078	0.089	0.617	1.492	0.003	0.072	0.051	0.008	0.013	0.055	0.047	0.002	0.005	347.164	0.004
Heavy-Duty Diesel Trucks	0.434	0.494	1.984	4.916	0.018	0.213	0.148	0.036	0.028	0.158	0.137	0.009	0.012	1895.307	0.020
Source	**Emission Factors (g/mi) - 2024**														
Construction Workers	0.352	0.375	2.554	0.278	0.004	0.040	0.019	0.008	0.013	0.025	0.018	0.002	0.005	314.182	0.021
Pick-up Trucks (Gasoline)	0.325	0.349	2.412	0.291	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.489	0.023
Pick-up Trucks (Diesel)	0.076	0.086	0.611	1.493	0.003	0.070	0.050	0.008	0.013	0.053	0.046	0.002	0.005	347.107	0.004
Heavy-Duty Diesel Trucks	0.407	0.463	1.880	4.544	0.018	0.198	0.134	0.036	0.028	0.144	0.123	0.009	0.012	1894.343	0.019
Source	**Emission Factors (g/mi) - 2025**														
Construction Workers	0.322	0.343	2.297	0.248	0.004	0.040	0.019	0.008	0.013	0.025	0.018	0.002	0.005	309.680	0.019
Pick-up Trucks (Gasoline)	0.309	0.332	2.260	0.267	0.005	0.052	0.032	0.008	0.013	0.037	0.029	0.002	0.005	503.549	0.022
Pick-up Trucks (Diesel)	0.074	0.084	0.608	1.493	0.003	0.068	0.048	0.008	0.013	0.051	0.044	0.002	0.005	346.702	0.003
Heavy-Duty Diesel Trucks	0.386	0.439	1.800	4.261	0.018	0.187	0.122	0.036	0.028	0.134	0.113	0.009	0.012	1893.663	0.018

Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Emission Factors (g/gal) - 2019															
Pick-up Trucks (Gasoline)	3.099	3.675	64.564	8.089	0.085	0.903	0.546	0.139	0.218	0.635	0.506	0.035	0.093	6853.123	0.535
Pick-up Trucks (Diesel)	2.391	2.721	18.554	42.953	0.096	2.139	1.542	0.233	0.365	1.633	1.419	0.058	0.156	7895.515	0.111
Heavy-Duty Gasoline Vehicles	38.397	41.971	1079.229	102.086	0.085	0.651	0.179	0.141	0.331	0.343	0.166	0.035	0.142	7040.659	3.104
Heavy-Duty Diesel Trucks	3.329	3.790	14.509	40.768	0.096	1.683	1.342	0.191	0.150	1.347	1.235	0.048	0.064	10080.002	0.155
Emission Factors (g/gal) - 2020															
Source	**ROG**	**TOG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**	**CH4**
Pick-up Trucks (Gasoline)	2.765	3.302	59.094	7.358	0.085	0.904	0.547	0.139	0.218	0.636	0.507	0.035	0.094	6624.024	0.501
Pick-up Trucks (Diesel)	2.340	2.664	18.312	43.091	0.096	2.110	1.512	0.233	0.365	1.606	1.391	0.058	0.156	7623.113	0.109
Heavy-Duty Gasoline Vehicles	30.459	33.476	977.395	98.842	0.085	0.668	0.181	0.145	0.342	0.351	0.168	0.036	0.146	7226.011	2.641
Heavy-Duty Diesel Trucks	3.004	3.420	13.256	36.040	0.096	1.504	1.163	0.191	0.150	1.182	1.070	0.048	0.064	10080.002	0.140
Emission Factors (g/gal) - 2023															
Source	**ROG**	**TOG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**	**CH4**
Pick-up Trucks (Gasoline)	2.023	2.474	45.355	5.560	0.085	0.909	0.551	0.140	0.219	0.639	0.511	0.035	0.094	6642.214	0.424
Pick-up Trucks (Diesel)	2.279	2.594	17.903	43.325	0.096	2.084	1.487	0.232	0.364	1.583	1.368	0.058	0.156	7623.112	0.106
Heavy-Duty Gasoline Vehicles	20.409	22.792	813.006	91.566	0.085	0.696	0.187	0.152	0.357	0.364	0.174	0.038	0.153	7516.216	2.127
Heavy-Duty Diesel Trucks	2.306	2.626	10.551	26.147	0.096	1.131	0.789	0.191	0.150	0.838	0.726	0.048	0.064	10079.996	0.107
Emission Factors (g/gal) - 2024															
Source	**ROG**	**TOG**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**	**CH4**
Pick-up Trucks (Gasoline)	1.820	2.249	42.095	5.076	0.085	0.910	0.552	0.140	0.219	0.641	0.512	0.035	0.094	6646.593	0.404
Pick-up Trucks (Diesel)	2.205	2.511	17.740	43.355	0.096	2.036	1.439	0.232	0.364	1.538	1.324	0.058	0.156	7623.115	0.102
Heavy-Duty Gasoline Vehicles	18.285	20.541	776.986	90.334	0.085	0.704	0.191	0.153	0.360	0.370	0.177	0.038	0.154	7579.538	2.025
Heavy-Duty Diesel Trucks	2.164	2.464	10.002	24.177	0.096	1.054	0.712	0.192	0.150	0.767	0.655	0.048	0.064	10080.007	0.101
Emission Factors (g/gal) - 2025															
Source	ROG	TOG	CO	NOx	SOx	PM10 Total	PM10 Exhaust	PM10 Tire Wear	PM10 Brake Wear	PM2.5 Total	PM2.5 Exhaust	PM2.5 Tire Wear	PM2.5 Brake Wear	CO2	CH4
Pick-up Trucks (Gasoline)	1.658	2.067	39.462	4.661	0.085	0.912	0.553	0.140	0.219	0.642	0.513	0.035	0.094	6650.133	0.387
Pick-up Trucks (Diesel)	2.150	2.448	17.664	43.395	0.096	1.989	1.392	0.233	0.365	1.495	1.281	0.058	0.156	7623.111	0.100
Heavy-Duty Gasoline Vehicles	14.981	17.039	710.425	89.275	0.085	0.717	0.196	0.155	0.365	0.377	0.182	0.039	0.157	7694.584	1.866
Heavy-Duty Diesel Trucks	2.055	2.339	9.581	22.680	0.096	0.993	0.652	0.192	0.150	0.712	0.599	0.048	0.064	10080.004	0.095

Notes:
Construction workers emissions only include LDA, LDT1, and LDT2 vehicle types, based on guidance from URBEMIS2007 User's Guide.
CO2 emission factors for construction workers adjusted to reflect the Pavley and LCFS using CARB's Pavley post-processor.
Pick-up trucks use LDT2 emission factors.

Table N8B. Summary of MOBILE 6.2 Emission Factors

	Emission Factors (g/mi) - 2019												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	0.530	10.446	0.408	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	467.9
Pick-Up Trucks (Gasoline)	0.596	10.789	0.473	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.228	0.486	0.295	0.006	0.039	0.018	0.008	0.013	0.024	0.017	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.498	8.250	0.713	0.016	0.036	0.015	0.009	0.013	0.021	0.013	0.002	0.005	905.9
Heavy-Duty Diesel Trucks	0.271	0.517	1.921	0.013	0.072	0.033	0.026	0.013	0.042	0.030	0.007	0.005	1395.4
	Emission Factors (g/mi) - 2020												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	0.504	10.304	0.396	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	468.8
Pick-Up Trucks (Gasoline)	0.564	10.613	0.459	0.009	0.024	0.004	0.008	0.013	0.011	0.003	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.212	0.465	0.271	0.006	0.038	0.017	0.008	0.013	0.023	0.016	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.459	8.206	0.637	0.016	0.035	0.014	0.009	0.013	0.020	0.012	0.002	0.005	905.6
Heavy-Duty Diesel Trucks	0.266	0.470	1.686	0.013	0.069	0.030	0.026	0.013	0.039	0.027	0.007	0.005	1395.6
	Emission Factors (g/mi) - 2022												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	0.461	10.125	0.373	0.009	0.024	0.004	0.008	0.013	0.011	0.004	0.002	0.005	468.8
Pick-Up Trucks (Gasoline)	0.511	10.400	0.434	0.009	0.024	0.004	0.008	0.013	0.011	0.003	0.002	0.005	516.1
Pick-Up Trucks (Diesel)	0.184	0.429	0.229	0.006	0.035	0.014	0.008	0.013	0.021	0.013	0.002	0.005	598.7
Heavy-Duty Gasoline Vehicles	0.393	8.126	0.492	0.016	0.033	0.012	0.009	0.013	0.018	0.011	0.002	0.005	905.6
Heavy-Duty Diesel Trucks	0.257	0.396	1.312	0.013	0.063	0.024	0.026	0.013	0.034	0.022	0.007	0.005	1395.6

	Emission Factors (g/gal) - 2019												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	10.379	204.664	7.998	0.168	0.477	0.075	0.157	0.245	0.213	0.070	0.039	0.104	9168.2
Pick-Up Trucks (Gasoline)	10.367	187.800	8.234	0.165	0.422	0.065	0.139	0.218	0.188	0.061	0.035	0.092	8983.0
Pick-Up Trucks (Diesel)	3.876	8.262	5.015	0.095	0.660	0.3111	0.136	0.213	0.410	0.286	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	4.893	81.036	7.008	0.161	0.351	0.143	0.085	0.123	0.203	0.130	0.021	0.052	8898.9
Heavy-Duty Diesel Trucks	2.102	4.017	14.910	0.101	0.559	0.257	0.204	0.097	0.329	0.236	0.051	0.041	10833.6
	Emission Factors (g/gal) - 2020												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	9.860	201.489	7.742	0.168	0.476	0.075	0.156	0.244	0.211	0.069	0.039	0.104	9166.8
Pick-Up Trucks (Gasoline)	9.815	184.734	7.997	0.165	0.422	0.065	0.139	0.218	0.187	0.060	0.035	0.092	8983.0
Pick-Up Trucks (Diesel)	3.604	7.905	4.607	0.095	0.638	0.289	0.136	0.213	0.389	0.265	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	4.514	80.624	6.264	0.161	0.342	0.134	0.085	0.123	0.194	0.121	0.021	0.052	8898.2
Heavy-Duty Diesel Trucks	2.061	3.647	13.079	0.101	0.532	0.230	0.204	0.097	0.304	0.212	0.051	0.041	10828.8
	Emission Factors (g/gal) - 2022												
Source	**VOC**	**CO**	**NOx**	**SOx**	**PM10 Total**	**PM10 Exhaust**	**PM10 Tire Wear**	**PM10 Brake Wear**	**PM2.5 Total**	**PM2.5 Exhaust**	**PM2.5 Tire Wear**	**PM2.5 Brake Wear**	**CO2**
Construction Worker	9.011	197.974	7.299	0.168	0.475	0.074	0.156	0.244	0.211	0.069	0.039	0.104	9167.5
Pick-Up Trucks (Gasoline)	8.890	181.029	7.557	0.165	0.421	0.064	0.139	0.218	0.187	0.060	0.035	0.092	8983.9
Pick-Up Trucks (Diesel)	3.128	7.293	3.893	0.095	0.593	0.245	0.136	0.213	0.349	0.224	0.034	0.090	10177.9
Heavy-Duty Gasoline Vehicles	3.859	79.841	4.830	0.161	0.326	0.119	0.085	0.123	0.181	0.107	0.021	0.052	8898.2
Heavy-Duty Diesel Trucks	1.997	3.072	10.181	0.101	0.488	0.186	0.204	0.097	0.264	0.172	0.051	0.041	10828.8

Appendix O
County Economic Descriptions

This appendix describes the regional economies, including income, employment, and industry data for each county in the socioeconomic area of analysis. The socioeconomic study area includes Del Norte, Humboldt, Mendocino, Modoc, and Siskiyou Counties in California and Curry, Klamath, and Jackson Counties in Oregon. The Lead Agencies collected socioeconomic data from state and federal sources. The descriptions of regional economics for Siskiyou and Klamath Counties are somewhat more detailed than for the other counties, because it is expected that most effects of dam removal would occur in these two counties. The regional economic descriptions provide snapshots of the overall economic conditions of the counties. In response to the economic recession, some counties received funding under the American Recovery and Reinvestment Act of 2009 (Recovery Act). A discussion of Recovery Act funds received by each county is at the end of this appendix.

O.1 County Economic Descriptions

O.1.1 Del Norte County

O.1.1.1 Population

In 2009, the population of Del Norte County was 29,556 (California Department of Finance [DOF] 2010a). Crescent City, the only incorporated city within the county, had a population of 7,669 (DOF 2010b).

O.1.1.2 Income

In 2008, Del Norte County had a per capita personal income (PCPI) of $25,980. The county's PCPI ranked last of California's 58 counties, was 59 percent of the state average of $43,852, and was 65 percent of the national average of $40,166. In 1998, the PCPI of Del Norte County was $16,825, which ranked 56th in the state. The 1998–2008 average annual growth rate of PCPI was 4.4 percent. In comparison, the average annual growth rate for California was 4.2 percent and for the nation was 4.0 percent (United States Bureau of Economic Analysis [BEA] 2010a).

Table O-1 shows the 2008 household income distribution in Del Norte County. The median household income was $35,861. The median household income for California in 2008 was $61,154, about $25,300 more than Del Norte County median income in 2008.

The mean household income in Del Norte County was $49,812 in 2008, compared to a mean household income of $83,970 in California (U.S. Census Bureau 2010a).

Table O-1. 2008 Household Income in Del Norte County

	Number	Percent
Households	9,693	--
Less than $10,000	704	7.3
$10,000 to $14,999	1,331	13.7
$15,000 to $24,999	1,730	17.8
$25,000 to $34,999	1,015	10.5
$35,000 to $49,999	1,202	12.4
$50,000 to $74,999	1,439	14.8
$75,000 to $99,999	1,078	11.1
$100,000 to $149,999	981	10.1
$150,000 to $199,999	146	1.5
$200,000 or more	67	0.7
Median household income (dollars)	35,861	--

Source: U.S. Census Bureau 2010a

From 1997 through 2008, the percentages of residents in Del Norte County below the poverty line ranged from 18.6 percent (in 2003) to 23.6 percent (in 2008) (Table O-2). During the same period, the percentage of residents that live below the poverty line in Del Norte County was greater than the percentage of residents who live below the poverty line in California.

Table O-2. Number and Percentage of People Living in Poverty in Del Norte County and California (1997-2008)

	Del Norte County		California	
Year	Number	Percent	Number	Percent
1997	5,523	22.9	5,195,477	16.0
1998	4,945	20.7	4,917,053	14.9
1999	4,633	19.5	4,562,089	13.7
2000	5,129	21.8	4,304,909	12.7
2001	5,122	21.6	4,418,040	12.9
2002	5,092	21.1	4,646,661	13.3
2003	4,590	18.6	4,836,106	13.7
2004	4,779	19.2	4,681,645	13.2
2005	5,547	22.5	4,669,056	13.3
2006	5,433	21.8	4,686,706	13.1
2007	5,565	22.3	4,445,392	12.4
2008	5,930	23.6	4,781,201	13.3

Source: U.S. Census Bureau 2010b

O.1.1.3 Industry and Employment

In 2005 and 2008, the industries with the highest earnings and employment in Del Norte County were government and government enterprises, health care and social assistance, and retail trade. From 2005 to 2008, total farm earnings decreased by 25 percent ($2.7 million and total nonfarm earnings increased by 16 percent ($61.1 million). Employment and earnings increased in the real estate industry from 2005 to 2008 (BEA 2010b). Earnings in the arts, entertainment, and recreational industry fell 79 percent ($584,000) (BEA 2010c). Data for trends in forestry, fishing, and related activities is unavailable for Del Norte County. Table O-3 shows industry earnings and employment in Del Norte County in 2005 and 2008.

Table O-3. Industry Earnings and Employment in Del Norte County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$398,458	11,193	$456,859	11,690	15%	4%
Farm	$10,928	366	$8,250	308	-25%	-16%
Nonfarm	$387,530	10,827	$448,609	11,382	16%	5%
Forestry, Fishing, And Related Activities	(D)	(D)	(D)	(D)	N/A	N/A
Mining	(D)	(D)	(D)	(D)	N/A	N/A
Utilities	(D)	(D)	(D)	(D)	N/A	N/A
Construction	$24,188	556	$20,152	495	-17%	-11%
Manufacturing	$9,720	229	$7,412	177	-24%	-23%
Wholesale Trade	(D)	(D)	(D)	(D)	N/A	N/A
Retail Trade	$35,742	1,329	$39,596	1,353	11%	2%
Transportation and Warehousing	$7,398	213	$6,965	215	-6%	1%
Information	$4,436	122	$4,639	127	5%	4%
Finance and Insurance	$5,126	160	$5,556	164	8%	3%
Real Estate and Rental and Leasing	$6,886	400	$8,574	449	25%	12%
Professional, Scientific, and Technical Services	$7,468	311	$9,452	343	27%	10%
Management of Companies and Enterprises	$0	0	(D)	(D)	N/A	N/A
Administrative and Waste Services	$1,940	168	(D)	(D)	N/A	N/A
Educational Services	$398	59	$1,230	80	209%	36%
Health Care and Social Assistance	$51,472	1,312	$62,441	1,547	21%	18%
Arts, Entertainment, and Recreation	$743	103	$159	93	-79%	-10%
Accommodation and Food Services	$16,766	1,072	$16,987	1,028	1%	-4%
Other Services, except Public Administration	$16,196	620	$17,629	614	9%	-1%
Government and Government Enterprises	$183,025	3,632	$223,553	3,912	22%	8%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 57 percent of businesses in Del Norte County had less than 4 employees, 77 percent had less than 10 employees, and 90 percent had less than 20 employees (Table O-4). In the forestry, fishing, hunting, and agricultural support industry, about 84 percent of businesses had less than 4 employees. In 2008, Del Norte had one establishment with more than 250 employees in the health care and social assistance industry (U.S. Census Bureau 2010c).

Table O-4. Numbers of Employees at Businesses in Del Norte County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	19	16	2	1	0	0	0	0	0
Utilities	1	0	0	1	0	0	0	0	0
Construction	65	56	5	4	0	0	0	0	0
Manufacturing	12	7	2	1	2	0	0	0	0
Wholesale Trade	10	6	1	1	2	0	0	0	0
Retail Trade	70	28	16	15	6	4	1	0	0
Transportation and Warehousing	12	4	4	2	1	1	0	0	0
Information	13	6	3	2	2	0	0	0	0
Finance and Insurance	25	14	9	2	0	0	0	0	0
Real Estate and Rental and Leasing	29	21	6	2	0	0	0	0	0
Professional, Scientific, and Technical Services	33	23	5	4	1	0	0	0	0
Management of Companies and Enterprises	1	0	0	0	0	1	0	0	0
Administrative and Support and Waste Management and Remediation Services	16	13	1	2	0	0	0	0	0
Educational Services	5	1	3	1	0	0	0	0	0
Health Care and Social Assistance	75	35	16	8	12	2	1	1	0
Arts, Entertainment, and Recreation	7	5	0	0	0	0	2	0	0
Accommodation and Food Services	74	31	17	17	9	0	0	0	0
Other Services (except Public Administration)	33	20	8	4	1	0	0	0	0
Total	500	286	98	67	36	8	4	1	0

Source: U.S. Census Bureau 2010c

The Del Norte County annual average unemployment rate remained higher than California's unemployment rate from 1998 through 2009 (Table O-5). The unemployment rate in Del Norte County has been about 5 or more percentage points higher than the state average during the 1998–2009 period. Unemployment during November 2010 was 13.7 percent (Employment Development Department [EDD] 2010a).

Table O-5. Annual Unemployment in Del Norte County and California, 1998-2009

Year	Del Norte County	California
1998	10.3%	6.0%
1999	8.0%	5.3%
2000	7.4%	4.9%
2001	8.0%	5.4%
2002	8.7%	6.7%
2003	8.5%	6.8%
2004	8.1%	6.2%
2005	7.5%	5.4%
2006	6.9%	4.9%
2007	7.5%	5.3%
2008	8.7%	7.2%
2009	12.2%	11.4%

Source: EDD 2010a

O.1.2 Humboldt County

O.1.2.1 Population

In 2009, the population of Humboldt County was 133,136 (DOF 2010a). The largest cities within Humboldt County in 2008 were Eureka, with a population of 25,994, Arcata, with a population of 17,608, and Fortuna, with a population of 11,345 (DOF 2010b).

O.1.2.2 Income

In 2008, Humboldt County had a PCPI of $33,329, was ranked 34th in the state, was 76 percent of the state average of $43,852, and was 83 percent of the national average of $40,166. In 1998, the PCPI of Humboldt County was $22,194, which ranked 35th in the state. The 1998–2008 average annual growth rate of PCPI was 4.1 percent. The average annual growth rate for the state was 4.2 percent and for the nation was 4.0 percent (BEA 2010b).

Table O-6 shows the 2008 household income distribution in Humboldt County. The median household income was $40,515. The median household income for California in

2008 was $61,154, about $20,600 more than Humboldt County median income in 2008. The mean household income in Humboldt County was $55,323 in 2008, compared with a mean household income of $83,970 in California (U.S. Census Bureau 2010d).

Table O-6. 2008 Household Income in Humboldt County

	Number	Percent
Households	52,570	--
Less than $10,000	4,177	7.9
$10,000 to $14,999	4,744	9.0
$15,000 to $24,999	7,993	15.2
$25,000 to $34,999	6,237	11.9
$35,000 to $49,999	8,008	15.2
$50,000 to $74,999	9,588	18.2
$75,000 to $99,999	5,083	9.7
$100,000 to $149,999	4,635	8.8
$150,000 to $199,999	1,063	2.0
$200,000 or more	1,042	2.0
Median household income (dollars)	40,515	--

Source: U.S. Census Bureau 2010d

From 1997 to 2008, the percentage of residents in Humboldt County below the poverty line ranged from 15.4 percent (in 2004) and 19.8 percent (in 2008) (Table O-7). During the same period, the percentage of residents that live below the poverty line in Humboldt County was greater than the percentage of residents who live below the poverty line in California.

Table O-7. Number and Percentage of Residents below the Poverty Level in Humboldt County and California 1997-2008

	Humboldt County		California	
Year	Number	Percent	Number	Percent
1997	22,332	18.5	5,195,477	16.0
1998	21,345	17.8	4,917,053	14.9
1999	20,312	16.4	4,562,089	13.7
2000	19,614	15.9	4,304,909	12.7
2001	19,550	15.8	4,418,040	12.9
2002	19,409	15.5	4,646,661	13.3
2003	19,629	15.7	4,836,106	13.7
2004	19,295	15.4	4,681,645	13.2
2005	20,367	16.5	4,669,056	13.3
2006	22,480	18.0	4,686,706	13.1
2007	21,180	16.9	4,445,392	12.4
2008	24,794	19.8	4,781,201	13.3

Source: U.S. Census Bureau 2010b

O.1.2.3 Industry and Employment

Industries with the highest earnings in Humboldt County were government and government enterprises (2005 and 2008), health care and social assistance (2005 and 2008), retail trade (2005) and construction (2008). Industries that employed the most people were government and government enterprises, retail trade, and health care and social assistance. From 2005 to 2008, total farm earnings decreased by 46 percent ($24.5 million) and total nonfarm earnings increased by 8 percent ($194 million). Both the construction and real estate industries had substantial decreases in earnings and employment from 2005 to 2008. Industries that had increased earnings and employment included retail trade and arts, entertainment, and recreation. Data for trends in forestry, fishing, and related activities was unavailable for Humboldt County (BEA 2010b, BEA 2010c). Table O-8 shows industry earnings and employment in Humboldt County in 2005 and 2008.

Table O-8. Industry Earnings and Employment in Humboldt County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employ-ment	Change in Earnings	Change in Employ-ment
Total	$2,510,861	71,375	$2,680,469	72,712	7%	2%
Farm	$52,816	1,431	$28,345	1,385	-46%	-3%
Nonfarm	$2,458,045	69,944	$2,652,124	71,327	8%	2%
Forestry, Fishing, And Related Activities	(D)	(D)	(D)	(D)	N/A	N/A
Mining	(D)	(D)	(D)	(D)	N/A	N/A
Utilities	$33,781	323	(D)	(D)	N/A	N/A
Construction	$207,186	5,092	$195,313	5,052	-6%	-1%
Manufacturing	$200,449	4,396	$152,488	3,892	-24%	-11%
Wholesale Trade	$53,169	1,495	$63,861	1,431	20%	-4%
Retail Trade	$276,864	9,320	$294,919	9,466	7%	2%
Transportation and Warehousing	$77,913	1,592	(D)	(D)	N/A	N/A
Information	$30,621	913	$37,412	950	22%	4%
Finance and Insurance	$103,515	1,963	$102,983	1,915	-1%	-2%
Real Estate and Rental and Leasing	$51,121	2,890	$35,237	3,173	-31%	10%
Professional, Scientific, and Technical Services	$112,290	3,689	$151,532	4,140	35%	12%
Management of Companies and Enterprises	$18,460	466	$15,687	314	-15%	-33%
Administrative and Waste Services	$56,247	2,591	$67,823	2,940	21%	13%
Educational Services	$7,168	665	$9,697	651	35%	-2%
Health Care and Social Assistance	$286,956	7,063	$327,226	7,465	14%	6%
Arts, Entertainment, and Recreation	$14,167	1,857	$17,835	2,004	26%	8%
Accommodation and Food Services	$87,045	5,393	$95,111	5,285	9%	-2%
Other Services, except Public Administration	$148,160	5,116	$163,732	5,054	11%	-1%
Government and Government Enterprises	$641,804	13,254	$738,989	13,847	15%	4%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 54 percent of businesses in Humboldt County had less than 4 employees, 77 percent had less than 10 employees, and 88 percent had less than 20 employees (Table O-9). In the forestry, fishing, hunting, and agricultural support industry, about 62 percent of businesses had less than 4 employees. For the retail trade industry, 41 percent of businesses had less than 4 employees (U.S. Census Bureau 2010c).

Table O-9. Numbers of Employees at Businesses in Humboldt County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	71	44	9	11	4	2	1	0	0
Utilities	8	6	0	0	1	0	0	1	0
Construction	394	272	68	28	24	2	0	0	0
Manufacturing	141	68	20	21	20	5	6	1	0
Wholesale Trade	117	59	24	21	10	2	1	0	0
Retail Trade	635	262	170	118	56	22	7	0	0
Transportation and Warehousing	89	52	12	12	9	4	0	0	0
Information	54	23	8	11	10	2	0	0	0
Finance and Insurance	168	91	40	24	10	1	2	0	0
Real Estate and Rental and Leasing	180	137	32	9	2	0	0	0	0
Professional, Scientific, and Technical Services	255	172	46	24	9	3	0	1	0
Management of Companies and Enterprises	14	6	4	2	2	0	0	0	0
Administrative and Support and Waste Management and Remediation Services	122	81	15	11	12	2	1	0	0
Educational Services	36	19	9	5	2	1	0	0	0
Health Care and Social Assistance	462	225	107	59	46	18	5	1	1
Arts, Entertainment, and Recreation	63	36	10	8	4	1	2	2	0
Accommodation and Food Services	358	112	81	89	66	9	0	1	0
Other Services (except Public Administration)	332	207	77	36	11	1	0	0	0
Industries Not Classified	10	10	0	0	0	0	0	0	0
Total	3509	1882	732	489	298	75	25	7	1

Source: U.S. Census Bureau 2010c

The Humboldt County annual average unemployment rate remained slightly higher than California's unemployment rate from 1998 to 2008 (Table O-10). In 2009, the unemployment rate was 11.2 percent, an increase of 3.8 percent from 2008, but slightly less than the state's rate. Unemployment during November 2010 was 11.2 percent in Humboldt County (EDD 2010a).

Table O-10. Annual Unemployment in Humboldt County and California, 1998-2008

Year	Humboldt County	California
1998	7.2%	6.0%
1999	6.5%	5.3%
2000	5.8%	4.9%
2001	6.0%	5.4%
2002	6.7%	6.7%
2003	6.9%	6.8%
2004	6.5%	6.2%
2005	6.2%	5.4%
2006	5.5%	4.9%
2007	5.9%	5.3%
2008	7.2%	7.2%
2009	11.0%	11.4%

Source: EDD 2010a

O.1.3 Mendocino County

O.1.3.1 Population

In 2009, the population of Mendocino County was 90,068 (DOF 2010a). The largest cities within Mendocino County in 2008 were Ukiah, with a population of 15,666, Fort Bragg, with a population of 6,848, and Willits, with a population of 5,064 (DOF 2010b).

O.1.3.2 Income

In 2008, Mendocino County had a PCPI of $36,162, which was ranked 30th in the state, was 82 percent of the state average of $43,852, and was 90 percent of the national average of $40,166. In 1998, the PCPI of Mendocino County was $23,755, which ranked 28th in the state. The 1998–2008 average annual growth rate of PCPI was 4.3 percent. The average annual growth rate for the state was 4.2 percent and for the nation was 4.0 percent (BEA 2010a).

Table O-11 shows the 2008 household income distribution in Mendocino County. The median household income was $43,307. The median household income for California in 2008 was $61,154, about $18,000 more than Mendocino County median income in 2008.

The mean household income in Mendocino County was $58,136 in 2008, compared to a mean household income of $83,970 in California (U.S. Census Bureau 2010e).

Table O-11. 2008 Household Income in Mendocino County

	Number	Percent
Households	33,734	--
Less than $10,000	2,631	7.8
$10,000 to $14,999	2,407	7.1
$15,000 to $24,999	4,856	14.4
$25,000 to $34,999	4,139	12.3
$35,000 to $49,999	5,159	15.3
$50,000 to $74,999	6,200	18.4
$75,000 to $99,999	3,603	10.7
$100,000 to $149,999	3,158	9.4
$150,000 to $199,999	877	2.6
$200,000 or more	704	2.1
Median household income (dollars)	43,307	--

Source: U.S. Census Bureau 2010e

From 1997 through 2008, the percentage of residents in Mendocino County below the poverty line ranged from 14.4 percent (in 2004) to 18.1 percent (in 1997) (Table O-12). During the same period, the percentage of residents that live below the poverty line in Mendocino County was greater than the percentage of residents who live below the poverty line in California.

Table O-12. Mendocino County Poverty Level

	Mendocino County		California	
Year	Number	Percent	Number	Percent
1997	15,071	18.1	5,195,477	16.0
1998	14,692	17.5	4,917,053	14.9
1999	13,306	15.6	4,562,089	13.7
2000	12,575	14.7	4,304,909	12.7
2001	12,854	14.9	4,418,040	12.9
2002	12,730	14.6	4,646,661	13.3
2003	12,788	14.6	4,836,106	13.7
2004	12,503	14.4	4,681,645	13.2
2005	14,524	17.0	4,669,056	13.3
2006	14,553	16.8	4,686,706	13.1
2007	13,060	15.4	4,445,392	12.4
2008	15,032	17.7	4,781,201	13.3

Source: U.S. Census Bureau 2010b

O.1.3.3 Industry and Employment

In 2005 and 2008, the industries with the highest earnings and employment in Mendocino County were government and government enterprises, retail trade, and health care and social assistance. Total farm earnings decreased by 69 percent ($6.7 million) and total nonfarm earnings increased by 8 percent ($129 million). Industries related to recreation, including retail trade, accommodation/food service, and arts, entertainment, and recreation all had declines in employment from 2005 to 2008. However, employment and earnings in forestry, fishing, and related activities increased from 2005 to 2008; earnings increased by 15 percent ($7.8 million) (BEA 2010b, BEA 2010c). Table O-13 shows industry earnings and employment in Mendocino County in 2008.

Table O-13. Industry Earnings and Employment in Mendocino County

Line Title	2005 Earnings ($1,000)	2005 Employ-ment	2008 Earnings ($1,000)	2008 Employ-ment	Change in Earnings	Change in Employ-ment
Total	$1,663,680	50,844	$1,785,651	50,879	7%	0%
Farm	$9,710	2,286	$2,993	1,934	-69%	-15%
Nonfarm	$1,653,970	48,558	$1,782,658	48,945	8%	1%
Forestry, Fishing, And Related Activities	$51,001	1,486	$58,830	1,675	15%	13%
Mining	$2,860	75	$3,560	107	24%	43%
Utilities	$13,170	136	$24,048	195	83%	43%
Construction	$163,626	3,890	$137,322	3,727	-16%	-4%
Manufacturing	$143,410	3,628	$139,778	3,329	-3%	-8%
Wholesale Trade	$46,617	1,052	$56,130	1,028	20%	-2%
Retail Trade	$206,467	6,232	$212,731	6,186	3%	-1%
Transportation and Warehousing	$38,892	835	$39,377	847	1%	1%
Information	$23,412	665	$21,810	551	-7%	-17%
Finance and Insurance	$38,546	1,168	$53,598	1,329	39%	14%
Real Estate and Rental and Leasing	$44,857	2,535	$34,402	2,576	-23%	2%
Professional, Scientific, and Technical Services	$59,506	2,584	$82,691	2,926	39%	13%
Management of Companies and Enterprises	$10,337	229	$13,285	262	29%	14%
Administrative and Waste Services	$48,942	2,124	$51,085	2,127	4%	0%
Educational Services	$7,697	542	$11,311	629	47%	16%
Health Care and Social Assistance	$185,795	4,832	$208,075	4,911	12%	2%
Arts, Entertainment, and Recreation	$12,312	1,292	$12,115	1,275	-2%	-1%
Accommodation and Food Services	$83,473	4,614	$89,696	4,473	7%	-3%
Other Services, except Public Administration	$100,319	3,128	$106,515	3,113	6%	0%
Government and Government Enterprises	$372,731	7,511	$426,299	7,679	14%	2%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 56 percent of businesses in Mendocino County had less than 4 employees, 78 percent had less than 10 employees, and 90 percent had less than 20 employees (Table O-14). In the forestry, fishing, hunting, and agricultural support industry, about 69 percent of businesses had less than 4 employees. For the retail trade industry, 50 percent of businesses had less than 4 employees (U.S. Census Bureau 2010c).

Table O-14. Numbers of Employees at Businesses in Mendocino County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	64	44	8	6	3	1	2	0	0
Mining, Quarrying, and Oil and Gas Extraction	2	0	0	2	0	0	0	0	0
Utilities	6	3	2	0	0	0	1	0	0
Construction	335	245	60	25	4	1	0	0	0
Manufacturing	143	55	27	20	24	11	5	1	0
Wholesale Trade	93	48	18	16	10	1	0	0	0
Retail Trade	490	245	122	68	36	11	7	1	0
Transportation and Warehousing	45	23	9	6	5	2	0	0	0
Information	49	25	12	8	4	0	0	0	0
Finance and Insurance	100	59	28	9	3	0	1	0	0
Real Estate and Rental and Leasing	132	104	12	14	2	0	0	0	0
Management of companies and enterprises	211	161	36	12	2	0	0	0	0
Management of Companies and Enterprises	10	3	2	2	3	0	0	0	0
Administrative and Support and Waste Management and Remediation Services	94	67	20	3	2	2	0	0	0
Educational Services	24	11	3	2	8	0	0	0	0
Health Care and Social Assistance	286	119	86	39	27	10	3	1	1
Arts, Entertainment, and Recreation	53	30	9	5	5	2	2	0	0
Accommodation and Food Services	321	112	79	72	50	7	1	0	0
Other Services (except Public Administration)	209	150	43	9	6	1	0	0	0
Industries Not Classified	3	1	1	1	0	0	0	0	0
Total	2670	1505	577	319	194	49	22	3	1

Source: U.S. Census Bureau 2010c

In 2008, Mendocino County's annual unemployment rate was 6.8 percent. In 2009, the annual unemployment rate had increased to 10.5 percent. The Mendocino County annual unemployment rate remained at or above California's unemployment rate from 1998 through 2007, and fell slightly below the State's rates in 2008 and 2009 (Table O-15). Unemployment during November 2010 was 11.4 percent in Mendocino County (EDD 2010a).

Table O-15. Annual Unemployment in Mendocino County and California, 1998-2009

Year	Mendocino County	California
1998	7.9%	6.0%
1999	6.8%	5.3%
2000	5.6%	4.9%
2001	5.9%	5.4%
2002	6.7%	6.7%
2003	6.9%	6.8%
2004	6.4%	6.2%
2005	5.8%	5.4%
2006	5.2%	4.9%
2007	5.5%	5.3%
2008	6.8%	7.2%
2009	10.5%	11.4%

Source: EDD 2010a

O.1.4 Modoc County

O.1.4.1 Population

In 2009, the population of Modoc County was 9,706 (DOF 2010a). Alturas, the only incorporated city in the county, had a population of 2,778 (DOF 2010b).

O.1.4.2 Income

In 2008, Modoc County had a PCPI of $32,196, which was ranked 39th in the state, was 73 percent of the state average of $43,852, and was 80 percent of the national average of $40,166. In 1998, the PCPI of Modoc County was $20,767, which ranked 45th in the state. The 1998-2008 average annual growth rate of PCPI was 4.5 percent. The average annual growth rate for the state was 4.2 percent and for the nation was 4.0 percent (BEA 2010a).

Table O-16 shows the 2009 household income distribution in Modoc County. The median household income was $34,007. The median household income for California in 2009 was $60,392, about $26,400 more than Modoc County median income in 2009. The mean household income in Modoc County was $47,694 in 2009, compared to a mean household income of $82,948 in California (U.S. Census Bureau 2010f).

Table O-16. 2009 Household Income in Modoc County

	Number	Percent
Households	3,773	--
Less than $10,000	300	8.0
$10,000 to $14,999	440	11.7
$15,000 to $24,999	654	17.3
$25,000 to $34,999	587	15.6
$35,000 to $49,999	514	13.6
$50,000 to $74,999	489	13.0
$75,000 to $99,999	346	9.2
$100,000 to $149,999	351	9.3
$150,000 to $199,999	65	1.7
$200,000 or more	27	0.7
Median household income (dollars)	34,007	--

Source: U.S. Census Bureau 2010f

From 1997 through 2008, the percentage of residents in Modoc County below the poverty line ranged from 15.5 percent (in 2004) to 21.5 percent (in 1998) (Table O-17). During the same period, the percentage of residents that live below the poverty line in Modoc County was greater than the percentage of residents who live below the poverty line in California.

Table O-17. Number and Percentage of People Living in Poverty in Modoc County and California (1997-2008)

	Modoc County		California	
Year	Number	Percent	Number	Percent
1997	1,919	21.1	5,195,477	16.0
1998	1,923	21.5	4,917,053	14.9
1999	1,746	19.0	4,562,089	13.7
2000	1,772	19.7	4,304,909	12.7
2001	1,651	18.3	4,418,040	12.9
2002	1,550	16.9	4,646,661	13.3
2003	1,545	16.6	4,836,106	13.7
2004	1,429	15.5	4,681,645	13.2
2005	1,853	20.4	4,669,056	13.3
2006	1,741	18.7	4,686,706	13.1
2007	1,746	19.6	4,445,392	12.4
2008	1,552	17.4	4,781,201	13.3

Source: U.S. Census Bureau 2010b

O.1.4.3 Industry and Employment

In 2005 and 2008, government and government enterprises represented about 40 percent of total earnings in Modoc County. Total earnings in retail trade were about $12 million and $13 million in 2005 and 2008, respectively. Total farm earnings increased from 2005 to 2008 by 30 percent ($5.6 million) and total nonfarm earnings increased 9 percent ($11.5 million). Employment in both farm and nonfarm industries stayed relatively constant (BEA 2010c). Table O-18 shows industry earnings and employment in Modoc County in 2008.

Table O-18. Industry Earnings and Employment in Modoc County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$144,692	4,595	$161,849	4,578	12%	0%
Farm	$18,560	614	$24,195	582	30%	-5%
Nonfarm	$126,132	3,981	$137,654	3,996	9%	0%
Forestry, Fishing, And Related Activities	(D)	(D)	$6,103	211	N/A	N/A
Mining	(D)	(D)	$113	14	N/A	N/A
Utilities	(D)	(D)	(D)	(D)	N/A	N/A
Construction	$8,486	275	(D)	(D)	N/A	N/A
Manufacturing	$223	46	(D)	(D)	N/A	N/A
Wholesale Trade	$5,776	147	$5,057	138	-12%	-6%
Retail Trade	$11,457	331	$12,985	374	13%	13%
Transportation and Warehousing	(D)	(D)	(D)	(D)	N/A	N/A
Information	(D)	(D)	(D)	(D)	N/A	N/A
Finance and Insurance	$1,984	70	$2,269	68	14%	-3%
Real Estate and Rental and Leasing	$2,718	209	$3,173	253	17%	21%
Professional, Scientific, and Technical Services	$2,238	102	(D)	(D)	N/A	N/A
Management of Companies and Enterprises	$0	0	$0	0	N/A	N/A
Administrative and Waste Services	(D)	(D)	(D)	(D)	N/A	N/A
Educational Services	(D)	(D)	(D)	(D)	N/A	N/A
Health Care and Social Assistance	(D)	(D)	(D)	(D)	N/A	N/A
Arts, Entertainment, and Recreation	(D)	(D)	(D)	(D)	N/A	N/A
Accommodation and Food Services	(D)	(D)	(D)	(D)	N/A	N/A
Other Services, except Public Administration	$8,949	450	$9,913	427	11%	-5%
Government and Government Enterprises	$63,271	1,345	$67,674	1,234	7%	-8%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 58 percent of businesses in Modoc County had less than 4 employees, 78 percent had less than 10 employees, and 91 percent had less than 20 employees (Table O-19). In the forestry, fishing, hunting, and agricultural support industry, all businesses had less than 4 employees. Only 4 businesses in the county had more than 50 employees (U.S. Census Bureau 2010c).

Table O-19. Numbers of Employees at Businesses in Modoc County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	3	3	0	0	0	0	0	0	0
Mining, Quarrying, and Oil and Gas Extraction	1	0	0	1	0	0	0	0	0
Utilities	3	1	0	0	1	1	0	0	0
Construction	30	24	5	1	0	0	0	0	0
Manufacturing	8	4	2	1	1	0	0	0	0
Wholesale Trade	33	15	8	7	3	0	0	0	0
Retail Trade	9	4	4	1	0	0	0	0	0
Transportation and Warehousing	2	0	2	0	0	0	0	0	0
Information	7	3	3	1	0	0	0	0	0
Finance and Insurance	10	9	1	0	0	0	0	0	0
Real Estate and Rental and Leasing	11	9	1	1	0	0	0	0	0
Professional, scientific, and technical services	1	0	0	0	1	0	0	0	0
Management of Companies and Enterprises	2	1	0	1	0	0	0	0	0
Administrative and Support and Waste Management and Remediation Services	19	6	5	1	4	2	1	0	0
Educational Services	4	3	0	0	1	0	0	0	0
Health Care and Social Assistance	23	11	5	6	1	0	0	0	0
Arts, Entertainment, and Recreation	11	8	0	3	0	0	0	0	0
Accommodation and Food Services	3	3	0	0	0	0	0	0	0
Other Services (except Public Administration)	3	3	0	0	0	0	0	0	0
Industries Not Classified	1	0	0	1	0	0	0	0	0
Total	180	104	36	24	12	3	1	0	0

Source: U.S. Census Bureau 2010c

In 2008, Modoc County's annual unemployment rate was 9.6 percent. In 2009, the annual unemployment rate had increased to 12.9 percent. The Modoc County annual unemployment rate remained above California's unemployment rate from 1998 through 2009 (Table O-20). Unemployment during November 2010 was 15.2 percent in Modoc County (EDD 2010a).

Table O-20. Annual Unemployment in Modoc County and California, 1998-2009

Year	Modoc County	California
1998	11.2%	6.0%
1999	8.6%	5.3%
2000	7.5%	4.9%
2001	6.9%	5.4%
2002	7.9%	6.7%
2003	8.7%	6.8%
2004	8.8%	6.2%
2005	8.1%	5.4%
2006	7.8%	4.9%
2007	8.1%	5.3%
2008	9.6%	7.2%
2009	12.9%	11.4%

Source: EDD 2010a

Modoc County ranked 38th of California's counties for value of agricultural production in 2009, with a total value of $108 million. Alfalfa hay, cattle and calves, and potatoes produced the highest values (U.S. Department of Agriculture 2010). Modoc County is 70 percent federally owned, with land in the Modoc National Forest and the Tule Lake and Clear Lake National Wildlife Refuges (NWRs).

O.1.5 Siskiyou County

In 2009, the population of Siskiyou County was 45,986, a decrease of about 0.06 percent from the 2008 population (DOF 2010a). In 2009, the largest cities within Siskiyou County were Yreka, with a population of 7,432, followed by Mount Shasta at 3,604, and Weed, at 3,019 (DOF 2010b). The 2050 population for Siskiyou County is projected to be 66,588, an increase of 21,954 from 2000 (DOF 2007). Table O-21 presents population projections for Siskiyou County from 2000 to 2050.

Table O-21. Siskiyou County Population Projections to 2050

Year	Population	Annual Change
2000	44,634	--
2010	47,109	5.5%
2020	51,283	8.9%
2030	55,727	8.7%
2040	60,656	8.8%
2050	66,588	9.8%

Source: DOF 2007

O.1.5.1 Income

In 2008, Siskiyou County had a PCPI of $32,681 (BEA 2010a). Siskiyou County's PCPI ranked 37th of California's 58 counties, was 75 percent of the state average of $43,852, and was 81 percent of the national average of $40,166. In 1998, the PCPI of Siskiyou County was $21,336, which ranked 41st in the state. The 1998–2008 average annual growth rate of PCPI was 4.4 percent, compared to the average annual growth rate of 4.2 percent for the state and 4.0 percent for the nation (BEA 2010a).

Table O-22 shows the 2008 household income distribution in Siskiyou County. The median household income was $36,171. The median household income for California in 2008 was $61,154, about $25,000 more than Siskiyou County median income in 2008. The mean household income in Siskiyou County was $48,277 in 2008, relative to a mean household income of $83,970 in California (U.S. Census Bureau 2010g).

Table O-22. 2008 Household Income in Siskiyou County

Household Income	Number	Percent
Less than $10,000	1,704	8.5
$10,000 to $14,999	2,505	12.5
$15,000 to $24,999	3,032	15.1
$25,000 to $34,999	2,509	12.5
$35,000 to $49,999	2,970	14.8
$50,000 to $74,999	3,611	18.0
$75,000 to $99,999	1,700	8.5
$100,000 to $149,999	1,282	6.4
$150,000 to $199,999	435	2.2
$200,000 or more	273	1.4
Total Households	20,021	--
Median household income (dollars)	36,171	--

Source: U.S. Census Bureau 2010g

According to the U.S. Census Bureau Small Area Income and Poverty Estimates (U.S. Census Bureau 2010b), from 1997 through 2008 the percentages of residents in Siskiyou County below the poverty line ranged from 15.1 percent (in 2004) to 19 percent (in 1997) (Table O-23). From 1997 through 2008, the percentage of residents that lived below the poverty line in Siskiyou County was greater than the percentage of residents who lived below the poverty line in California.

Table O-23. Number and Percentage of People Living in Poverty in Siskiyou County and California (1997–2008)

Year	Siskiyou County		California	
	Number	Percent of County Population	Number	Percent of State Population
1997	8,337	19.0	5,195,477	16.0
1998	8,022	18.4	4,917,053	14.9
1999	7,458	17.0	4,562,089	13.7
2000	7,235	16.7	4,304,909	12.7
2001	7,046	16.2	4,418,040	12.9
2002	6,877	15.6	4,646,661	13.3
2003	6,896	15.6	4,836,106	13.7
2004	6,775	15.1	4,681,645	13.2
2005	7,771	17.5	4,669,056	13.3
2006	7,853	17.6	4,686,706	13.1
2007	7,754	17.7	4,445,392	12.4
2008	7,182	16.4	4,781,201	13.3

Source: U.S. Census Bureau 2010b

O.1.5.2 Industry and Employment

In both 2005 and 2008, the industries with the highest earnings and employment in Siskiyou County were government and government enterprises, health care and social assistance, and retail trade. From 2005 to 2008, total farm earnings decreased by 28 percent ($8.3 million) and total nonfarm earnings increased by 9 percent ($66.6 million). Construction and transportation and warehousing industries remained relatively constant from 2005 through 2008, while industry earnings in real estate, rental, and leasing fell 35 percent ($5.9 million) (BEA 2010b). Table O-24 shows industry earnings and employment in Siskiyou County in years 2005 and 2008.

Table O-24. Industry Earnings and Employment in Siskiyou County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$740,619	22,014	$798,941	22,497	8%	2%
Farm	$30,040	1,117	$21,719	1,039	-28%	-7%
Nonfarm	$710,579	20,897	$777,222	21,458	9%	3%
Forestry, Fishing, And Related Activities	(D)	(D)	(D)	(D)	N/A	N/A
Mining	(D)	(D)	(D)	(D)	N/A	N/A
Utilities	(D)	(D)	(D)	(D)	N/A	N/A
Construction	$50,583	1,448	$46,620	1,450	-8%	0%
Manufacturing	$40,041	952	$43,428	958	8%	1%
Wholesale Trade	(D)	(D)	(D)	(D)	N/A	N/A
Retail Trade	$67,772	2,373	$69,392	2,303	2%	-3%
Transportation and Warehousing	$46,352	859	$46,313	859	0%	0%
Information	$17,296	315	$17,515	305	1%	-3%
Finance and Insurance	$14,284	420	$17,693	466	24%	11%
Real Estate and Rental and Leasing	$17,026	955	$11,124	1,018	-35%	7%
Professional, Scientific, and Technical Services	$23,180	971	$26,985	1,021	16%	5%
Management of Companies and Enterprises	$6,192	102	$6,507	99	5%	-3%
Administrative and Waste Services	$9,144	791	$11,040	854	21%	8%
Educational Services	$1,796	146	$2,385	179	33%	23%
Health Care and Social Assistance	$78,981	2,241	$96,250	2,329	22%	4%
Arts, Entertainment, and Recreation	$5,479	599	$5,447	599	-1%	0%
Accommodation and Food Services	$28,661	1,779	$34,113	1,863	19%	5%
Other Services, except Public Administration	$45,395	1,381	$47,687	1,386	5%	0%
Government and Government Enterprises	$213,072	4,460	$242,990	4,533	14%	2%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

During the past 10 years, there has been a sharp decline in the Siskiyou County timber industry, which has been an economic base for the county historically. Table O-25 presents the Siskiyou County timber harvest from 2000 through 2009. In 2009, the total value of the timber harvest in Siskiyou County was $11.6 million, about a $52 million decrease from 2000 (Board of Equalization [BOE] 2010). Timber harvesting also decreased and was at its lowest value in 2009 over the 10-year period. Reductions in timber harvesting have also reduced employment opportunities in the county. In 2008, the county had 29 forestry and logging businesses, a decrease from 43 businesses from 1998. The number of forestry support businesses decreased from 10 to 7 during the same period (U.S. Census Bureau 2010c).

Table O-25. Siskiyou County Timber Harvest – Public and Private Lands

Year	Volume		Value	
	Net MBF	Percent of State	Value ($)	Percent of State
2000	193,408	9.84	$63,797,993	7.02
2001	134,829	8.41	$36,224,679	6.29
2002	187,215	11.08	$40,458,236	8.95
2003	230,871	13.88	$45,481,123	10.16
2004	239,349	14.03	$51,565,369	10.31
2005	207,726	12.04	$47,567,015	8.70
2006	198,832	12.19	$47,924,733	8.97
2007	246,141	15.14	$59,343,592	12.51
2008	147,278	10.73	$27,042,757	8.36
2009	118,512	14.72	$11,648,293	11.74

Source: BOE 2009, BOE 2010

MBF = thousand board feet, where one board foot = 1 inch by 12 inch by 1 foot board

In 2010, the major employers in Siskiyou County were schools and federal, state, and county governments. Table O-26 presents major employers in Siskiyou County, including some private enterprises.

Table O-26. Major Employers in Siskiyou County

Employer Name	Location	Industry
Schools		
College of the Siskiyous	Weed	Schools - Universities and Colleges Academic
Jackson Street Elementary School	Yreka	Schools
County Government		
Behavioral Health Services	Yreka	County Government - Public Health Programs
Siskiyou County Alcohol & Drug	Yreka	Drug Abuse and Addiction Information and Treatment
County Sheriff	Yreka	Sheriff
Siskiyou County Coroner	Yreka	Sheriff
Siskiyou County Sheriff's Office	Dunsmuir	Police Departments
Siskiyou County Public Works	Yreka	Grading Contractors
State Government		
Forestry and Fire Protection	Yreka	Government - Forestry Services
Federal Government		
Klamath National Forest	Yreka	Government - Forestry Services
Us Forestry Department	Happy Camp	Government - Forestry Services
Private Enterprise		
CCDA Waters LLC[1]	Mount Shasta	Water Companies – Bottled and Bulk
Mercy Medical Center Mount Shasta[2]	Mount Shasta	Hospitals
Electro-Guard Inc.	Mount Shasta	Manufacturers
Fairchild Medical Center	Yreka	Hospitals
Mt. Shasta Resort	Mount Shasta	Resorts
Raley's	Yreka	Grocers - Retail
Roseburg Forest Products	Weed	Plywood and Veneers
Siskiyou Golden Fair	Yreka	Associations
Siskiyou Lake LLC	Mount Shasta	Resorts
Sugar Creek Ranch	Etna	Guide Service
Sunwest Inc.	Yreka	Convalescent Homes
Timber Products Co.	Yreka	Softwood Veneer and Plywood
Union Pacific Railroad Company	Dunsmuir	Railroads
Walmart	Yreka	Department Stores

Source: EDD 2010b

Notes

1. CCDA Waters closed at the end of 2010.
2. Mercy Medical has closed the Care Center of its operations in Mt. Shasta. This was a layoff of about 50 employees.

Many businesses in Siskiyou County are small businesses, either sole proprietors or with a small number of employees. According to the Censtats Database by the U.S. Census Bureau, in 2008, 61 percent of businesses in Siskiyou County had less than 4 employees; 82 percent had less than 10 employees, and 93 percent had less than 20 employees (U.S. Census Bureau 2010c). Table O-27 shows total number of businesses and number of employees in 2008 in Siskiyou County. In 2003, the county had a total of 1,284 businesses (U.S. Census Bureau 2010c). Between 2003 and 2008, retail trade and health care and social assistance had the largest reduction in businesses of any industry, a reduction of 25 and 20 businesses, respectively. Construction businesses increased by 17 businesses in the 5 year period; however, all of them had less than 20 employees and 77 percent had one to four employees. In 2008, Siskiyou County had 28 truck transportation businesses in the transportation and warehousing industry, 24 of which had one to four employees (U.S. Census Bureau 2010h).

Table O-27. Numbers of Employees at Businesses in Siskiyou County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	40	26	10	2	2	0	0	0	0
Mining	4	3	1	0	0	0	0	0	0
Utilities	11	8	1	1	1	0	0	0	0
Construction	179	138	33	8	0	0	0	0	0
Manufacturing	37	18	6	5	3	2	3	0	0
Wholesale Trade	37	19	9	5	2	2	0	0	0
Retail Trade	208	97	62	30	15	3	1	0	0
Transportation and Warehousing	42	29	8	3	1	1	0	0	0
Information	26	10	7	5	4	0	0	0	0
Finance and Insurance	73	46	19	7	1	0	0	0	0
Real Estate and Rental and Leasing	63	55	6	1	1	0	0	0	0
Professional, Scientific, and Technical Services	100	74	19	6	1	0	0	0	0
Management of Companies and Enterprises	5	2	1	1	1	0	0	0	0
Administrative and Support and Waste Management and Remediation Services	45	36	5	2	1	0	1	0	0
Educational Services	8	3	3	1	1	0	0	0	0
Health Care and Social Assistance	117	61	19	22	9	4	0	2	0
Arts, Entertainment, and Recreation	25	15	3	5	1	0	0	1	0
Accommodation and Food Services	146	50	40	27	25	4	0	0	0
Other Services (except Public Administration)	106	81	16	8	1	0	0	0	0
Unclassified	5	5	0	0	0	0	0	0	0
Total	1,277	776	268	139	70	16	5	3	0

Source: U.S. Census Bureau 2010c

The Siskiyou County annual average unemployment rate remained higher than California's unemployment rate from 1998 through 2009 (Table O-28). The unemployment rate in Siskiyou County was at least 3 percentage points higher than the state average through the 1998–2009 period. Unemployment during November 2010 was 17.5 percent. The cities of Weed and Yreka had unemployment rates of 26.6 percent and 15.6 percent, respectively, in November 2010 (EDD 2010b). Unemployment rates in 2009 and 2010 have been the highest the county has had in the past 20 years.

Table O-28. Annual Unemployment for Siskiyou County and California, 1998-2008

Year	Siskiyou County	California
1998	12.6%	6.0%
1999	10.4%	5.3%
2000	7.5%	4.9%
2001	8.1%	5.4%
2002	8.9%	6.7%
2003	9.5%	6.8%
2004	9.5%	6.2%
2005	9.1%	5.4%
2006	8.0%	4.9%
2007	8.5%	5.3%
2008	10.1%	7.2%
2009	14.8%	11.4%

Source: EDD 2010a

Siskiyou County was ranked 29th in the California's 58 counties for agricultural value of production in 2009. In 2009, the total value of agricultural production was $212 million. The highest value crops were strawberry plants, alfalfa hay, and field crops (U.S. Department of Agriculture 2010). Cattle and timber are also important parts of the economy.

O.1.6 Curry County

O.1.6.1 Population

In 2010, Curry County's population was 21,160 (Portland State University 2010). In 2010, the largest cities in Curry County were Brookings, with a population of 6,490, followed by Gold Beach, at 2,140, and Port Orford at 1,315 (Portland State University 2010).

O.1.6.2 Income

In 2008, Curry County had a PCPI of $33,645 (U.S. Census Bureau 2010g). This PCPI ranked 10th in the state, was 93 percent of the state average of $36,365, and was 84 percent of the national average of $40,166. In 1998, the PCPI of Curry County was $21,983, which ranked 16th in the state. The 1998–2008 average annual growth rate of

PCPI was 4.3 percent. The average annual growth rate for the state was 3.4 percent and for the nation was 4.0 percent (BEA 2010a).

Table O-29 shows the 2008 household income distribution in Curry County. The median household income was $33,722. The median household income for Oregon in 2008 was $49,863, about $16,000 more than Curry County median income in 2008. The mean household income in Curry County was $47,013 in 2008, compared to a mean household income of $64,956 in Oregon (U.S. Census Bureau 2010i).

Table O-29. 2008 Household Income in Curry County

	Number	Percent
Households	10,461	--
Less than $10,000	1,214	11.6
$10,000 to $14,999	1,134	10.8
$15,000 to $24,999	1,563	14.9
$25,000 to $34,999	1,478	14.1
$35,000 to $49,999	1,249	11.9
$50,000 to $74,999	1,705	16.3
$75,000 to $99,999	1,107	10.6
$100,000 to $149,999	770	7.4
$150,000 to $199,999	195	1.9
$200,000 or more	46	0.4
Median household income (dollars)	33,722	--

Source: U.S. Census Bureau 2010i

From 1997 through 2008 the percentage of residents in Curry County below the poverty line ranged from 12.3 percent (2003) and 15 percent (in 1998) (see Table O-30). During the same period, the percentage of residents that live below the poverty line in Curry County was greater than the percentage of residents who live below the poverty line in Oregon.

Table O-30. Number and Percentage of People Living in Poverty in Curry County and Oregon (1997-2008)

	Curry County		Oregon	
Year	Number	Percent	Number	Percent
1997	2,951	13.9	379,506	11.6
1998	3,214	15	400,952	12.1
1999	2,801	13.3	379,250	11.3
2000	2,703	12.9	361,280	10.6
2001	2,884	13.6	382,706	11.1
2002	2,813	12.9	396,157	11.3
2003	2,713	12.3	423,253	12
2004	2,895	13	462,212	12.9
2005	2,898	13.1	497,318	14.1
2006	3,291	14.9	487,358	13.4
2007	3,044	14.1	476,647	13
2008	3,147	14.8	501,475	13.5

Source: U.S. Census Bureau 2010b

O.1.6.3 Industry and Employment

In 2005 and 2008, the industries with the highest earnings in Curry County were government and government enterprises, retail trade, construction, and manufacturing. Earnings in retail trade as well as arts, entertainment, and recreation remained relatively constant, while earnings in accommodation and food services increased. Total farm earnings decreased 23 percent ($1.1 million) and total nonfarm earnings increased by 7 percent ($20.8 million) (BEA 2010b). Table O-31 shows industry earnings and employment in Curry County in 2005 and 2008.

Table O-31. Industry Earnings and Employment in Curry County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$309,990	11,320	$331,814	11,641	7%	3%
Farm	$4,760	324	$5,832	318	23%	-2%
Nonfarm	$305,230	10,996	$325,982	11,323	7%	3%
Forestry, Fishing, And Related Activities	(D)	(D)	(D)	(D)	N/A	N/A
Mining	(D)	(D)	(D)	(D)	N/A	N/A
Utilities	(D)	(D)	(D)	(D)	N/A	N/A
Construction	$34,274	1,133	$28,254	1,090	-18%	-4%
Manufacturing	$34,543	750	$37,111	830	7%	11%
Wholesale Trade	(D)	(D)	(D)	(D)	N/A	N/A
Retail Trade	$37,913	1,612	$37,427	1,499	-1%	-7%
Transportation and Warehousing	$5,323	193	$6,175	203	16%	5%
Information	$2,910	139	$3,188	138	10%	-1%
Finance and Insurance	$9,247	262	$12,897	296	39%	13%
Real Estate and Rental and Leasing	$9,136	672	$9,830	821	8%	22%
Professional, Scientific, and Technical Services	$11,190	452	(D)	(D)	N/A	N/A
Management of Companies and Enterprises	(D)	(D)	(D)	(D)	N/A	N/A
Administrative and Waste Services	(D)	(D)	$8,102	515	N/A	N/A
Educational Services	(D)	(D)	$693	65	N/A	N/A
Health Care and Social Assistance	(D)	(D)	$23,417	969	N/A	N/A
Arts, Entertainment, and Recreation	$1,326	220	$1,317	254	-1%	15%
Accommodation and Food Services	$21,081	1,295	$22,780	1,237	8%	-4%
Other Services, except Public Administration	$17,745	649	$19,939	689	12%	6%
Government and Government Enterprises	$61,054	1,312	$63,763	1,269	4%	-3%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 61 percent of businesses in Curry County had less than 4 employees, 83 percent had less than 10 employees, and 93 percent had less than 20 employees (Table O-32). In the forestry, fishing, hunting, and agricultural support industry, about 63 percent of businesses had less than 4 employees. Only 11 businesses in the county had more than 50 employees: 3 of them were in manufacturing and 3 were in health care and social assistance (U.S. Census Bureau 2010c).

Table O-32. Numbers of Employees at Businesses in Curry County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	27	17	5	3	2	0	0	0	0
Mining	2	1	0	1	0	0	0	0	0
Utilities	3	0	1	0	2	0	0	0	0
Construction	125	98	19	6	1	1	0	0	0
Manufacturing	21	12	3	2	1	0	2	1	0
Wholesale Trade	13	10	3	0	0	0	0	0	0
Retail Trade	101	48	24	17	11	0	0	1	0
Transportation and Warehousing	18	13	3	1	1	0	0	0	0
Information	11	5	4	1	1	0	0	0	0
Finance and Insurance	34	18	14	1	0	1	0	0	0
Real Estate and Rental and Leasing	57	48	8	1	0	0	0	0	0
Professional, Scientific, and Technical Services	39	32	4	2	1	0	0	0	0
Management of Companies and Enterprises	1	0	0	0	0	0	1	0	0
Administrative and Support and Waste Management and Remediation Services	20	13	4	0	2	1	0	0	0
Educational Services	4	1	2	0	1	0	0	0	0
Health Care and Social Assistance	89	41	28	13	4	2	1	0	0
Arts, Entertainment, and Recreation	15	10	2	3	0	0	0	0	0
Accommodation and Food Services	106	40	30	25	11	0	0	0	0
Other Services (except Public Administration)	54	43	7	4	0	0	0	0	0
Unclassified	5	5	0	0	0	0	0	0	0
Total	745	455	161	80	38	5	4	2	0

Source: U.S. Census Bureau 2010c

Table O-33 shows annual unemployment rate in Curry County and Oregon from 1998 to 2009. The 2009 unemployment rate was the highest of the 12-year period (Oregon Employment Department 2010a). During the period shown, Curry County consistently had higher unemployment rates than the state. In November 2010, Curry County had an unemployment rate of 13.2 percent and the state had an unemployment rate of 10.6 percent (Oregon Employment Department 2010b).

Table O-33. Annual Unemployment Rate for Curry County and Oregon

Year	Curry County	Oregon
1998	9.3%	6.0%
1999	7.1%	5.3%
2000	7.0%	4.9%
2001	7.2%	5.4%
2002	8.1%	6.7%
2003	8.4%	6.8%
2004	7.5%	6.2%
2005	7.0%	5.4%
2006	6.8%	4.9%
2007	6.5%	5.3%
2008	8.0%	7.2%
2009	13.1%	11.4%

Source: Oregon Employment Department 2010a

O.1.7 Jackson County

O.1.7.1 Population

In 2010, Jackson County's population was 207,745 (Portland State University 2010). In 2010, the largest cities in Jackson County were Medford, with a population of 77,485, followed by Ashland, at 21,460, and Eagle Point at 8,855 (Portland State University 2010).

O.1.7.2 Income

In 2008, Jackson County had a PCPI of $34,506. This PCPI ranked 8th in the state, was 95 percent of the state average of $36,365, and was 86 percent of the national average of $40,166. In 1998, the PCPI of Jackson County was $23,088, which ranked 11th in the state. The 1998–2008 average annual growth rate of PCPI was 4.1 percent. The average annual growth rate for the state was 3.4 percent and for the nation was 4.0 percent (BEA 2010a).

Table O-34 shows the 2008 household income distribution in Jackson County. The median household income was $43,748. The median household income for Oregon in 2008 was $49,863, about $6,000 more than Jackson County's median income in 2008.

The mean household income in Jackson County was $57,803 in 2008, compared to a mean household income of $64,956 in Oregon (U.S. Census Bureau 2010j).

Table O-34. 2008 Household Income in Jackson County

	Number	Percent
Households	81,559	--
Less than $10,000	6,218	7.6
$10,000 to $14,999	4,918	6.0
$15,000 to $24,999	10,725	13.1
$25,000 to $34,999	10,502	12.9
$35,000 to $49,999	13,080	16.0
$50,000 to $74,999	16,330	20.0
$75,000 to $99,999	9,495	11.6
$100,000 to $149,999	6,731	8.3
$150,000 to $199,999	1,968	2.4
$200,000 or more	1,592	2.0
Median household income (dollars)	43,784	--

Source: U.S. Census Bureau 2010j

From 1997 through 2008, the percentage of residents in Jackson County below the poverty line range from 12.8 percent (in 2000) to 16 percent (in 2008) (Table O-35). From 1997 through 2004, the percentage of residents that live below the poverty line in Jackson County was greater than the percentage of residents who live below the poverty line in the state. Poverty rates in the county were similar to those of the state from 2005 through 2007. In 2008, people in poverty in Jackson County rose to 16 percent, which was 2.5 percent higher than the state rate.

Table O-35. Number and Percentage of People Living in Poverty in Jackson County and California (1997-2008)

	Jackson County		Oregon	
Year	Number	Percent	Number	Percent
1997	23,924	13.8	379,506	11.6
1998	25,870	13.7	400,952	12.1
1999	24,135	13.5	379,250	11.3
2000	23,266	12.8	361,280	10.6
2001	24,274	13.2	382,706	11.1
2002	24,629	13.1	396,157	11.3
2003	25,256	13.3	423,253	12
2004	26,976	14.0	462,212	12.9
2005	25,875	13.6	497,318	14.1
2006	25,204	13.0	487,358	13.4
2007	26,133	13.4	476,647	13
2008	31,611	16.0	501,475	13.5

Source: U.S. Census Bureau 2010b

O.1.7.3 Industry and Employment

In 2005 and 2008, the industries with the highest earnings and employment in Jackson County were health care and social assistance, government and government enterprises, and retail trade. Construction employment and earnings decreased from 2005 to 2008, while trends for transportation and warehousing were unavailable. In 2008, the transportation and warehousing sector represented about 5 percent of total Jackson County earnings. Total farm earnings decreased 30 percent from 2005 to 2008 ($5.2 million), while total nonfarm earnings increased by 6 percent ($240 million) (BEA 2010b). Table O-36 shows industry earnings and employment in Jackson County in 2005 and 2008.

Table O-36. Industry Earnings and Employment in Jackson County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$4,214,405	115,710	$4,448,124	120,099	6%	4%
Farm	$17,546	2,926	$12,304	2,802	-30%	-4%
Nonfarm	$4,196,859	112,784	$4,435,820	117,297	6%	4%
Forestry, Fishing, And Related Activities	$81,432	2,399	$99,548	2,461	22%	3%
Mining	$9,240	285	$8,147	366	-12%	28%
Utilities	(D)	(D)	(D)	(D)	N/A	N/A
Construction	$529,222	8,885	$435,234	8,405	-18%	-5%
Manufacturing	$319,811	7,723	$333,057	8,068	4%	4%
Wholesale Trade	(D)	(D)	(D)	(D)	N/A	N/A
Retail Trade	$549,807	16,990	$542,478	16,221	-1%	-5%
Transportation and Warehousing	(D)	(D)	$196,096	3,652	N/A	N/A
Information	$92,605	2,219	$95,690	2,175	3%	-2%
Finance and Insurance	$150,056	3,770	$163,199	4,495	9%	19%
Real Estate and Rental and Leasing	$93,803	5,673	$70,306	6,640	-25%	17%
Professional, Scientific, and Technical Services	$155,033	5,070	$191,899	5,829	24%	15%
Management of Companies and Enterprises	$114,881	1,750	$116,014	1,752	1%	0%
Administrative and Waste Services	$153,984	5,972	$159,671	6,104	4%	2%
Educational Services	$23,577	1,321	$26,486	1,371	12%	4%
Health Care and Social Assistance	$614,588	14,005	$727,805	15,327	18%	9%
Arts, Entertainment, and Recreation	$47,746	2,991	$56,391	3,581	18%	20%
Accommodation and Food Services	$153,498	8,687	$165,915	8,777	8%	1%
Other Services, except Public Administration	$193,880	6,658	$218,645	6,824	13%	2%
Government and Government Enterprises	$596,743	11,875	$662,327	12,016	11%	1%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

In 2008, 54 percent of businesses in Jackson County had less than 4 employees, 75 percent had less than 10 employees, and 88 percent had less than 20 employees (Table O-37). In the forestry, fishing, hunting, and agricultural support industry, about 64 percent of businesses had less than 4 employees. The county had 221 businesses with more than 50 employees (U.S. Census Bureau 2010c).

Table O-37. Numbers of Employees at Businesses in Jackson County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	94	60	10	9	8	5	2	0	0
Mining	7	1	3	1	1	1	0	0	0
Utilities	12	4	2	1	2	3	0	0	0
Construction	827	580	141	68	29	7	2	0	0
Manufacturing	320	137	79	39	35	16	11	3	0
Wholesale Trade	250	113	59	48	25	3	2	0	0
Retail Trade	922	384	268	138	90	20	15	7	0
Transportation and Warehousing	192	92	42	19	23	9	5	1	1
Information	115	49	32	17	12	2	2	1	0
Finance and Insurance	375	232	85	39	13	4	1	1	0
Real Estate and Rental and Leasing	337	260	44	25	6	2	0	0	0
Professional, Scientific, and Technical Services	500	351	88	41	15	3	2	0	0
Management of Companies and Enterprises	34	15	5	2	5	2	2	2	1
Administrative and Support and Waste Management and Remediation Services	290	184	43	26	24	7	5	0	1
Educational Services	76	39	12	17	6	2	0	0	0
Health Care and Social Assistance	632	287	157	96	60	18	10	2	2
Arts, Entertainment, and Recreation	106	52	19	20	7	4	3	1	0
Accommodation and Food Services	602	184	132	158	109	15	4	0	0
Other Services (except Public Administration)	461	280	106	47	19	5	4	0	0
Unclassified	8	8	0	0	0	0	0	0	0
Total	6,160	3,312	1,327	811	489	128	70	18	5

Source: U.S. Census Bureau 2010c

Table O-38 shows annual unemployment rate in Jackson County and Oregon from 1998 to 2009. The 2009 unemployment rate was the highest of the 12-year period (Oregon Employment Department 2010a). Jackson County in general had unemployment rates that were greater than or similar to those of the state from 1998 through 2009. In November 2010, Jackson County had an unemployment rate of 13.7 percent and the state had an unemployment rate of 10.6 percent (Oregon Employment Department 2010b).

Table O-38. Annual Unemployment Rate for Jackson County and Oregon

Year	Jackson County	Oregon
1997	7.3%	6.0%
1998	7.2%	5.3%
1999	6.4%	4.9%
2000	5.6%	5.4%
2001	6.6%	6.7%
2002	7.5%	6.8%
2003	7.7%	6.2%
2004	7.1%	5.4%
2005	6.2%	4.9%
2006	5.7%	5.3%
2007	5.6%	7.2%
2008	7.8%	11.4%
2009	12.6%	6.0%

Source: Oregon Employment Department 2010a

O.1.8 Klamath County

In 2010, Klamath County had a population of 66,475 (Portland State University 2010). Klamath Falls is the largest city in Klamath County, with a 2010 population estimate of 21,480 (Portland State University 2010).

O.1.8.1 Income

In 2008, Klamath County had a PCPI of $29,138, which ranked 30th of Oregon's 36 counties, was 80 percent of the state average of $36,365, and was 73 percent of the national average of $40,166. In 1998, the PCPI of Klamath County was $20,079, which ranked 28th in the state. The 1998–2008 average annual growth rate of PCPI was 3.8 percent, compared with the average annual growth rate of 3.4 percent for the state and 4.0 percent for the nation (BEA 2010a).

Table O-39 shows the 2008 household income distribution in Klamath County. The median household income was $42,255. The median household income for Oregon in 2008 was $49,863, about $7,600 more than Klamath County's median income in 2008.

The mean household income in Klamath County was $54,698 in 2008, relative to a mean household income of $64,956 in Oregon (U.S. Census Bureau 2010k).

Table O-39. 2008 Household Income in Klamath County

	Number	Percent
Households	26,908	--
Less than $10,000	2,383	8.9
$10,000 to $14,999	1,799	6.7
$15,000 to $24,999	3,932	14.6
$25,000 to $34,999	3,346	12.4
$35,000 to $49,999	3,985	14.8
$50,000 to $74,999	5,605	20.8
$75,000 to $99,999	2,836	10.5
$100,000 to $149,999	2,137	7.9
$150,000 to $199,999	296	1.1
$200,000 or more	589	2.2
Median household income (dollars)	42,255	--

Source: U.S. Census Bureau 2010k

From 1997 through 2008 the percentages of residents in Klamath County below the poverty line ranges from 13.6 percent (in 2002) to 20.3 percent (in 2005) (Table O-40). During the same period, the percentage of residents that lived below the poverty line in Klamath County was greater than the percentage of residents who lived below the poverty line in the state.

Table O-40. Number and Percentage of People Living in Poverty in Klamath County and Oregon (1997-2008)

	Klamath County		Oregon	
Year	Number	Percent	Number	Percent
1997	10,091	15.9	379,506	11.6
1998	10,763	16.9	400,952	12.1
1999	9,935	15.8	379,250	11.3
2000	9,072	14.3	361,280	10.6
2001	9,290	14.7	382,706	11.1
2002	9,435	13.6	396,157	11.3
2003	9,746	15.3	423,253	12.0
2004	10,800	16.6	462,212	12.9
2005	13,062	20.3	497,318	14.1
2006	11,919	18.4	487,358	13.4
2007	10,358	15.9	476,647	13.0
2008	11,023	17.0	501,475	13.5

Source: U.S. Census Bureau 2010b

O.1.8.2 Industry and Employment

In both 2005 and 2008, the industries with the highest earnings in Klamath County were government and government enterprises, health care and social assistance, and manufacturing. From 2005 to 2008, employment in construction and transportation/ warehousing industries stayed relatively constant, while employment in real estate, rental, and leasing increased by 28 percent (365 persons) (U.S. Census Bureau 2010c). Earnings in the industry of arts, entertainment, and recreation increased from $6.7 million to $9.9 million, while employment increased by 99 persons. Total farm earnings decreased by 7 percent ($2.2 million) and total nonfarm earnings increased by 7 percent ($77 million) in the same time period (BEA 2010b). Table O-41 shows industry earnings and employment in Klamath County in 2005 and 2008.

Table O-41. Industry Earnings and Employment in Klamath County

Line Title	2005 Earnings ($1,000)	2005 Employment	2008 Earnings ($1,000)	2008 Employment	Change in Earnings	Change in Employment
Total	$1,146,752	33,579	$1,221,576	34,439	7%	3%
Farm	$32,224	1,772	$30,066	1,752	-7%	-1%
Nonfarm	$1,114,528	31,807	$1,191,510	32,687	7%	3%
Forestry, Fishing, And Related Activities	(D)	(D)	(D)	(D)	N/A	N/A
Mining	(D)	(D)	(D)	(D)	N/A	N/A
Utilities	$12,110	124	$14,917	130	23%	5%
Construction	$58,231	1,857	$55,552	1,855	-5%	0%
Manufacturing	$127,960	2,805	$115,795	2,473	-10%	-12%
Wholesale Trade	$35,624	905	$39,852	951	12%	5%
Retail Trade	$101,132	4,080	$108,552	4,152	7%	2%
Transportation and Warehousing	$64,487	1,002	$65,954	1,037	2%	3%
Information	$11,157	365	$11,047	314	-1%	-14%
Finance and Insurance	$28,701	832	$34,270	930	19%	12%
Real Estate and Rental and Leasing	$15,355	1,287	$13,889	1,652	-10%	28%
Professional, Scientific, and Technical Services	(D)	(D)	(D)	(D)	N/A	N/A
Management of Companies and Enterprises	(D)	(D)	(D)	(D)	N/A	N/A
Administrative and Waste Services	$33,178	1,604	$41,648	1,772	26%	10%
Educational Services	$3,244	247	$4,899	297	51%	20%
Health Care and Social Assistance	$136,827	3,792	$157,539	3,947	15%	4%
Arts, Entertainment, and Recreation	$6,663	568	$9,862	667	48%	17%
Accommodation and Food Services	$47,373	2,569	$49,312	2,668	4%	4%
Other Services, except Public Administration	$54,630	1,918	$61,247	2,035	12%	6%
Government and Government Enterprises	$269,567	5,559	$289,013	5,469	7%	-2%

Source: BEA 2010b, BEA 2010c

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

Similar to Siskiyou County, timber harvests in Klamath County have been declining in recent years. Table O-42 shows annual timber harvests from 2000 through 2009. Timber harvests in 2008 and 2009 showed substantial decreases relative to previous years. Klamath County received federal funds associated with timber harvesting on federal lands. In fiscal year 2009, Klamath County received $2.2 million in Secure Rural Schools Act payments.

Table O-42. Klamath County Timber Harvest – Public and Private Lands

	Volume	
Year	Net MBF	Percent of State
2000	178,999	4.6%
2001	212,130	6.2%
2002	207,693	5.3%
2003	198,669	5.0%
2004	171,215	3.8%
2005	190,273	4.4%
2006	152,557	3.5%
2007	107,127	2.8%
2008	67,470	2.0%
2009	76,829	2.8%

Source: Oregon Department of Forestry 2005, 2006, 2007, 2008, 2009, 2010

MBF = thousand board feet, where one board foot = 1 inch by 12 inch by 1 foot board

In 2008, 56 percent of businesses in Klamath County had less than 4 employees, 77 percent had less than 10 employees, and 89 percent had less than 20 employees (Table O-43). In the forestry, fishing, hunting, and agricultural support industry, about 67 percent of businesses had less than 4 employees. For the construction industry, 68 percent of businesses had less than 4 employees. Between 2003 and 2008, total businesses in Klamath County increased by 96. Largest increases in the number of businesses were in construction (32), accommodation and food services (23), and real estate and rental and leasing (18). Largest decreases in businesses between 2003 and 2008 were in unclassified businesses (13), wholesale trade (6), forestry, fishing, hunting and agricultural support (5) and other services (5) (U.S. Census Bureau 2010c). In 2008, in the construction industry, only 8 businesses had more than 20 employees. The businesses with 50–99 employees were asphalt and road building contractors. Water and sewer construction and heavy construction businesses all had less than 9 employees. Klamath County has 15 freight trucking employers, most of which generally haul commodities palletized and transported in a container or van trailer. Except for a moving company, all other transportation employers had less than 9 employees (Oregon Employment Department 2011).

Table O-43. Numbers of Employees at Businesses in Klamath County, by Industry, 2008

Industry	Total Businesses	Number of Employees							
		1–4	5–9	10–19	20–49	50–99	100–249	250–499	500 or more
Forestry, Fishing, Hunting, and Agriculture Support	43	29	5	6	3	0	0	0	0
Mining	6	4	0	2	0	0	0	0	0
Utilities	18	11	5	0	2	0	0	0	0
Construction	202	138	36	19	6	2	1	0	0
Manufacturing	71	25	14	7	10	6	5	4	0
Wholesale Trade	63	28	15	12	8	0	0	0	0
Retail Trade	256	117	70	38	19	9	1	2	0
Transportation and Warehousing	75	47	17	8	3	0	0	0	0
Information	26	14	5	5	1	0	1	0	0
Finance and Insurance	74	38	23	7	4	1	0	0	1
Real Estate and Rental and Leasing	95	74	13	4	2	2	0	0	0
Professional, Scientific, and Technical Services	125	84	23	11	6	0	1	0	0
Management of Companies and Enterprises	4	0	2	1	0	0	0	0	1
Administrative and Support and Waste Management and Remediation Services	67	44	10	6	5	0	2	0	0
Educational Services	15	7	3	3	2	0	0	0	0
Health Care and Social Assistance	213	115	47	25	18	5	2	0	1
Arts, Entertainment, and Recreation	23	11	3	2	6	0	1	0	0
Accommodation and Food Services	179	70	34	34	35	5	1	0	0
Other Services (except Public Administration)	172	106	45	15	5	1	0	0	0
Unclassified	1	1	0	0	0	0	0	0	0
Total	1,728	963	370	205	135	31	15	6	3

Source: U.S. Census Bureau 2010c

Table O-44 shows annual unemployment rate in Klamath County and Oregon from 1998 through 2009. The 2009 unemployment rate was the highest of the 12-year period (Oregon Employment Department 2010a). Klamath County has consistently had higher unemployment rates than the state. In November 2010, Klamath County had an unemployment rate of 14.2 percent and the state had an unemployment rate of 10.6 percent (Oregon Employment Department 2010b).

Table O-44. Annual Unemployment Rate for Klamath County and Oregon, 1998-2008

Year	Klamath County	Oregon
1998	9.7%	6.0%
1999	8.5%	5.3%
2000	7.4%	4.9%
2001	8.6%	5.4%
2002	9.0%	6.7%
2003	9.8%	6.8%
2004	9.4%	6.2%
2005	7.7%	5.4%
2006	6.7%	4.9%
2007	6.9%	5.3%
2008	9.1%	7.2%
2009	13.8%	11.4%

Source: Oregon Employment Department 2010a

Klamath County contains over half of the area of Reclamation's Klamath Project. In 2009, the county's agricultural production was valued at $241 million; cattle, hay, and specialty crops were the top three producers.

O.2 Recovery Act of 2009 Funding in Affected Counties

In response to the economic crisis, the Federal government passed the American Recovery and Reinvestment Act of 2009 to create new jobs and spur economic activity. The Recovery Act provides $288 billion in tax cuts and benefits for millions of working families and businesses, increased federal funds for education and health care as well as entitlement programs (such as extending unemployment benefits) by $224 billion and makes $275 billion available for federal contracts, grants and loans. Counties in the economic area of analysis have received Recovery Act funds to help offset effects of the economic recession. Table O-45 summarizes funds received by county from February 17, 2009 through March 31, 2011.

Table O-45. Recovery Act Funds Received from February 17, 2009 to March 31, 2011 by County (Million $)

County	Contracts	Grants	Loans	Total[1]
Del Norte	4.2	18.3	0	22.5
Humboldt	6.9	113.2	5.3	125.3
Mendocino	12.5	57.6	0	70.1
Modoc	6.2	8.7	0	14.9
Siskiyou	25.7	30.2	7.6	63.5
Curry	7.2	5.9	0	13.2
Jackson	17.4	88.9	0	106.4
Klamath	5.9	49.0	0.96	55.9

Source: Recovery.gov

1- Totals may not add due to rounding

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Appendix P
KBRA Regional Economic Effects IMPLAN Analysis

P.1 Introduction

This appendix evaluates the regional economic effects of implementing the Klamath Basin Restoration Agreement (KBRA). The KBRA includes up to 112 actions that could result in new economic activity in the counties within the Klamath Basin. KBRA actions would increase purchases and employment opportunities through planning and implementation of local projects and would provide funding to local governments.

Actions in the KBRA are grouped under fisheries programs, water and power programs, regulatory assurances, and county and tribal programs. The fisheries programs include an extensive habitat restoration program throughout the basin; fisheries reintroduction programs; fisheries monitoring programs; and actions intended to increase flows and reliability of instream water in the mainstem of the Klamath River and its tributaries (with the exception of the Trinity River basin). The water and power programs include an agreement on limitations on water diversions to Reclamation's Klamath Project users including the Klamath Basin National Wildlife Refuge System; a voluntary Water Use Retirement Plan (WURP) to allow for more instream water for fisheries; and agreements and assurances that the parties will work collaboratively to resolve outstanding water right contests through the Oregon Klamath Basin Adjudication process. County and tribal programs include: economic development programs for local governments and tribes; regulatory assurances that adverse impacts on communities would be minimized; and tribal fisheries and natural resource conservation management programs. Chapter 2 of the EIS/EIR describes KBRA actions under each program.

The KBRA includes Appendix C-2 Budget for Implementation of Agreement that provides estimates for the costs of implementing the KBRA. The Klamath Settlement Parties developed Appendix C-2 in 2008. Federal agencies have since revised Appendix C-2 funds and extended the KBRA to 15-year period from 2012 through 20026. This analysis uses the Revised Appendix C-2, Cost Estimates or Federal Funding to Implement Klamath Basin Restoration Agreement, dated June 20, 2011 (hereon referred to as Revised Appendix C-2). The Revised Appendix C-2 is attached at the end of this appendix.

KBRA actions would require further discretionary approval by federal or state agencies and would be subject to subsequent NEPA and/or CEQA compliance; therefore, this is a preliminary analysis of potential regional economic effects of implementing the KBRA.

In addition, funding for the KBRA is still being identified and negotiated; therefore, program costs could change in the future. This is a preliminary analysis with the best available information at this time.

P.2 Methods

Implementation of KBRA actions in the Klamath Basin would increase economic activity, including employment, labor income, and output, over the 15 year implementation period. This analysis uses program costs and the IMPLAN (IMpact analysis for PLANning) model to estimate regional economic effects of each KBRA action. See Section 3.15, Socioeconomics, for discussion of IMPLAN. In general, IMPLAN estimates the economic impacts of a change in final demand within an industry or institution. IMPLAN provides economic data for the defined region, including number of jobs, labor income and output for each sector. This analysis is based on a 2009 regional economy defined using IMPLAN data sets.

The IMPLAN model has some inherent limitations to assessing economic effects. It is an input-output modeling framework that does not incorporate price changes, technology changes, and changes in behavior. The model is static and provides a snap shot of the economy at a given point in time. Thus, the model does not consider long-term adjustments that the economy will make in response to this change. Other model limitations include:

- IMPLAN is used to examine “marginal” changes: Estimated jobs and income coefficients are valid only for relatively small changes to a particular area’s economy in the IMPLAN baseline year. Any stimulus large enough to change the underlying structure and trade relationships of the economy will necessarily change the relationships quantified in the coefficients and new models would need to be specified and run.
- Multipliers are not generic: These coefficients reflect a unique underlying economic structure. They are not, therefore, generally applicable to activities and geographies different from those under which they were originally estimated.
- Secondary job and income effects vary based on size of an economy: Larger study areas will typically have more internalization of economic activity thus leading to larger multipliers.

P.2.1 Economic Regions

This analysis mostly uses two economic regions (groups of counties): a 4-county region consisting of Klamath, Siskiyou, Humboldt, and Del Norte Counties, and a 3-county region consisting of Klamath, Siskiyou, and Modoc Counties. The applicable region depends on where the action would occur. For example, actions in the fisheries programs would occur in the 4-county region and actions affecting Reclamation’s Klamath Project would occur in the 3-county region. For some actions, individual counties are used if the effect is likely to occur in a particular county. The results sections identify regions used for the analysis of each action.

P.2.2 Revised Appendix C-2 Cost Escalation

The economic analysis for the Secretarial Determination uses values estimated in 2012 dollars. The Revised Appendix C-2 shows estimated costs in 2007 dollars. For actions with a construction, monitoring, or restoration component, it is necessary to escalate costs to 2012 dollars to reflect inflation and for consistency with base funding and other economic analyses. Costs were escalated using the Gross Domestic Product (GDP) implicit price deflator index, which was 1.09, to escalate from 2007 to 2012 dollars. The 2011 and 2012 indexes were projected based on compound average growth rate for previous five years. This analysis escalated total action costs. For actions that involve transfer of funds from one entity to another, costs were assumed to be nominal dollars and not escalated.

P.2.3 Project Timing

This analysis uses the total funds over the 15-year period and does not evaluate effects on an annual basis. The total cost of the action was run in IMPLAN in the event year 2012; however, economic effects would occur over the 15-year time period or during the years in which the action is implemented. Therefore, some effects presented in the results could be greater over time due to inflation if the action is implemented in later years. The Revised Appendix C-2 identifies the years in which the projects would be implemented. IMPLAN is a linear model; therefore, effects would occur in proportion to the dollars that are spent annually. Economic effects are presented in 2012 dollars.

P.2.4 Base Funding

Federal agencies identified initial base funding values, provided in 2012 dollars, for actions similar to those that would be implemented under the KBRA. Base funding was provided on an annual basis for each year from 2012-2026. Not all actions have base funding. The base funding dollars are assumed to be spent whether the KBRA is implemented or not; therefore, the base funding values are assumed for the No Action Alternative. Base funding values were run in IMPLAN to determine effects of the No Action Alternative. Base funding values are preliminary and may change in the future from those used in this analysis.

The KBRA funding would be in addition to the base funding that would be spent under the No Action Alternative. Base funding was subtracted from the total, escalated KBRA costs for the Facilities Removal Alternatives.

P.2.5 In-Region Spending

KBRA actions encompass a wide range of activities ranging from facility construction to plan development to transfer payments to local governments and private entities. Most activities, including construction projects, restoration, and monitoring activities, would result in some level of a change in final demand within the region. Some actions, such as transfer payments, would result in an exchange of funds from one entity to another. There would be no regional economic effects of the exchange of funds. Future spending of the funds would have regional effects, but they cannot be quantified at this time.

For projects that would result in regional economic effects, it is important to determine how much money would be spent within the region versus outside of the region. Money spent outside of the region would not affect employment, labor income, or output within the region and is not considered in this analysis. To estimate in-region spending, project experts from federal and state agencies and tribes were interviewed regarding the percentage of total costs that would be spent in the region. Experts were from U.S. Fish and Wildlife Service, Bureau of Reclamation, NOAA Fisheries Service, United State Geologic Survey, U.S. Forest Service, U.S. Department of the Interior, California Department of Fish and Game, Oregon Department of Fish and Wildlife, Karuk Tribe, Yurok Tribe and The Klamath Tribes. Personal communication references are included at the end of this appendix. Project experts considered project requirements, similar past projects, existing industries and work force in the counties to determine a percentage for in-region costs. Percentages were applied to both base funding and additional KBRA funding. These percentages should be reexamined as KBRA actions are further defined and analyzed prior to implementation. Table P-1 shows in-region federal spending for actions with base funding and actions with incremental KBRA funding that are analyzed in this appendix.

Once in-region spending percentages were agreed upon, project experts helped identify the appropriate industry or institution that would experience the direct economic effect, or change in demand. For the majority of actions, money would be spent in the construction sector or in local and state governments to implement activities.

Construction dollars are input into Sector 36 Construction of Other Non-Residential Structures in IMPLAN. For funds to state and local governments, spending was modeled using an institutional spending pattern for State/Local Government Non-Education developed for the region within IMPLAN. Some funds would also be spent on local scientists or consultants; these direct effects are input into Sector 375 Environmental and Other Technical Consulting Services in IMPLAN. After the appropriate sectors were identified, IMPLAN used model specific multipliers to estimate direct and secondary effects. Multipliers exist for every component of value added i.e. output, employment and labor income. Tables P-2 and P-3 show 2009 regional economic production function or multipliers for Sector 36 Construction of Other Non-Residential Structures and Sector 375 Environmental and Other Technical Consulting Services within the 4-county (Klamath, Siskiyou, Del Norte, and Humboldt Counties) and 3-county (Klamath, Siskiyou and Modoc Counties) regions for employment, labor income and output.

Table P-1. In-Region Base and KBRA Funding Summary (2012 dollars, 1000$)

#	Action	BASE FUNDING	KBRA FUNDING (incremental to Base Funding)
1	Coordination and Oversight	$1,350	$117
2	Planning & Implementation Ph. I and Ph. II Restoration Plans	$420	$1,211
3	Williamson R. aquatic habitat restoration	$3,735	$890
4	Sprague R. aquatic habitat restoration	$11,216	$41,994
5	Wood R. Valley aquatic habitat restoration	$2,997	$10,777
6	Williamson Sprague Wood Screening Diversion	$0	$2,232
7	Williamson & Sprague USFS uplands	$4,680	$4,886
8	Upper Klamath Lake aquatic habitat restoration	$2,997	$10,785
9	Screening of UKL pumps	$0	$425
10	UKL watershed USFS uplands	$1,159	$1,641
11	Keno Res. water quality studies & remediation actions	$0	$29,647
12	Keno Res. wetlands restoration	$2,250	$1,008
14	Keno to Iron Gate upland USFS (Goosenest)	$504	$713
15	Keno to Iron Gate mainstem restoration	$0	$951
16	Keno to Iron Gate tributaries - diversions & riparian	$0	$1,141
17	Shasta River aquatic habitat restoration	$16,674	$0
18	Shasta River USFS uplands	$606	$0
19	Scott River aquatic habitat restoration	$18,720	$0
20	Scott River USFS uplands	$958	$460
21	Scott River private uplands	$2,100	$0
22	Mid Klamath River & tributaries (Iron Gate to Weitchpec) aquatic habitat restoration	$6,750	$0
23	Mid Klamath tributaries USFS upland	$3,600	$4,574
24	Mid Klamath tributaries private upland	$4,200	$1,887
25	Lower Klamath River & tributaries (Weitchpec to mouth) aquatic habitat restoration	$18,200	$0
26	Lower Klamath private uplands	$9,900	$25,428
27	Salmon River aquatic habitat restoration	$1,650	$1,959
28	Salmon River USFS upland	$2,082	$2,701
29	Reintroduction Plan	$0	$1,631
30	Collection Facility	$0	$6,014
31	Production Facility	$0	$6,113
32	Acclimation Facility	$0	$4,709
33	Transport	$0	$826
34	Monitoring and Evaluation - Oregon	$0	$29,828
35	Monitoring and Evaluation - California	$0	$2,995
36	New Hatchery (Iron Gate Dam or Fall Creek)	$0	$5,546
37	Adult Salmonids	$7,400	$9,952
38	Juvenile Salmonids	$4,110	$14,630
39	Genetics Otololith	$2,055	$0
40	Hatchery Tagging	$315	$0
41	Disease	$316	$5,214
42	Green Sturgeon	$2,480	$0
43	Lamprey	$371	$1,837
44	Geomorphology	$153	$1,608
45	Habitat Monitoring	$0	$2,641
46	Water Quality	$1,545	$86
47	UKL bloom dynamics	$1,545	$0
48	UKL water quality/phytoplankton/zooplankton	$2,020	$4,143
49	UKL internal load/bloom dynamics	$1,800	$1,244
50	UKL external nutrient loading	$60	$3,881
51	UKL analysis of long-term data sets	$0	$652

Table P-1. In-Region Base and KBRA Funding Summary (2012 dollars, 1000$)

#	Action	BASE FUNDING	KBRA FUNDING (incremental to Base Funding)
52	UKL listed suckers	$8,985	$4,331
53	Tributaries water quality/nutrients/sediment	$0	$4,718
54	Tributaries geomorphology/riparian vegetation	$0	$3,637
55	Tributaries physical habitat	$0	$3,241
56	Tributaries listed suckers	$930	$4,777
57	Keno Impoundment water quality/algae/nutrients	$70	$6,048
58	Keno Impoundment to Tributaries: Meteorology (weather stations)	$0	$3,044
61	Data Analysis and evaluation	$0	$168
62	Development of predictive techniques	$0	$391
64	Klamath Basin Wildlife Refuges: Walking Wetland Construction	$0	$2,500
66	On Project water plan	$4,325	$96,223
69	D Pumping Plant	$0	$2,772
73	Federal Power	$0	$1,087
74	Energy Efficiency and Renewable Resources	$0	$4,402
76	UKL Wetlands Restoration: Agency/Barnes	$0	$2,717
77	UKL Wetlands Restoration: Wood River	$0	$2,717
85	Real Time Water Management: Water Flow Monitoring and Gauges	$0	$3,239
87	Adaptive Management: Science and Analysis	$0	$1,087
88	Real Time Management: Calibration and improvements to KLAMSIM or other modeling and predictions	$0	$109
90	Keno Impoundment Klamath Irrigation Project Screening	$0	$5,470
91	Federal General/Habitat Conservation Plan	$0	$5,082
100	Fisheries Management Karuk	$10,468	$4,032
101	Fisheries Management Klamath	$8,997	$5,503
102	Fisheries Management Yurok	$8,934	$5,566
104	Conservation Management Karuk	$4,200	$3,050
105	Conservation Management Klamath	$4,200	$3,050
106	Conservation Management Yurok	$4,200	$3,050
108	Economic Development Study Karuk	$0	$250
109	Economic Development Study Klamath	$0	$250
110	Economic Development Study Yurok	$0	$250

Source: Revised Appendix C-2
UKL: Upper Klamath Lake
USFS: United States Forest Service

Table P-2. 4-County (Klamath, Siskiyou, Humboldt, and Del Norte) Multiplier

Industry sector	Employment		Labor income		Output	
	Direct Effects	Secondary Effects	Direct Effects	Secondary Effects	Direct Effects	Secondary Effects
Sector 36: Construction of Other Non-Residential Structures	8.608	5.176	0.417	0.201	1.000	0.546
Sector 375: Environmental and Other Technical Consulting Services	14.370	6.492	0.571	0.232	1.000	0.639

Source: 2009 IMPLAN data

Table P-3. 3-County (Klamath, Siskiyou, and Modoc) Multiplier

	Employment		Labor income		Output	
Industry sector	**Direct Effects**	**Secondary Effects**	**Direct Effects**	**Secondary Effects**	**Direct Effects**	**Secondary Effects**
Sector 36: Construction of Other Non-Residential Structures	9.2652	4.473	0.450	0.1392	1.000	0.3940
Sector 375: Environmental and Other Technical Consulting Services	11.375	5.836	0.618	0.194	1.000	0.540

Source: 2009 IMPLAN data

P.2.6 Project Not Evaluated in this Appendix

Some KBRA actions would affect irrigated agriculture and wildlife refuges in Reclamation's Klamath Project area. These effects were evaluated separately and are described in the Irrigated Agriculture Economics Technical Report and the Refuge Recreation Technical Report. Actions include: On-Project Water Plan, Water Use Retirement Plan, Off-Project Program, Interim Power Sustainability, Drought Plan Restoration Fund Agreement, Interim Flow and Lake Level Program. These programs would have some additional regional effects from funds spent in state and local governments on administration and implementation. These actions are not evaluated in this appendix to avoid double counting of economic effects.

Based on project expert opinions obtained through interviews, some KBRA actions would be implemented completely outside of the region. In the future, portions of these actions could be implemented in-region, but this information is not available at the time of this analysis. Therefore, it is assumed the following actions would not have any regional economic effects and are not evaluated in this appendix: Remote Sensing Acquisition and Analysis, Keno Dam Fish Passage, Groundwater Technical Investigation, Technical Assessment of Climate Change, and Renewable Power Program Financial and Engineering Plan.

Some actions originally identified in the KBRA do not have funding identified in the Revised C-2 Appendix. These projects are identified in Section P.4.

P.3 2009 Regional Economy

Tables P-4 and P-5 show 2009 regional economic data for the 4-county (Klamath, Siskiyou, Del Norte, and Humboldt Counties) and 3-county (Klamath, Siskiyou and Modoc Counties) regions aggregated into eight industry sector classifications. Employment is measured in number of jobs. Income is the dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals within the analysis area. Output represents the dollar value of industry production.

Table P-4. 4-County (Klamath, Siskiyou, Humboldt, and Del Norte) Regional Economy

Industry sector	Employment		Labor income		Output	
	Jobs	Percent of total	Million $	Percent of total	Million $	Percent of total
Agriculture	5,713	4.8	219.0	4.5	910.7	7.3
Mining	127	0.1	5.6	0.1	23.1	0.2
Construction	5,845	4.9	282.1	5.7	707.4	5.7
Manufacturing	5,085	4.2	261.9	5.3	1,501.9	12.0
Transportation, Information, Public Utilities	3,887	3.2	215.1	4.4	759.6	6.1
Trade	17,471	14.6	601.1	12.2	1,232.5	9.9
Service	53,658	44.8	1,835.7	37.4	5,459.1	43.7
Government	28,048	23.4	1,490.2	30.3	1,904.5	15.2
Total	**119,834**		**4,910.7**		**12,498.8**	

Source: 2009 IMPLAN data

Table P-5. 3-County (Klamath, Siskiyou, and Modoc) Regional Economy

Industry sector	Employment		Labor income		Output	
	Jobs	Percent of total	Million $	Percent of total	Million $	Percent of total
Agriculture and fishing	3,803	7.3	124.2	6.0	560.9	10.2
Mining	85	0.2	3.3	0.2	16.1	0.3
Construction	2,358	4.5	99.3	4.8	265.5	4.8
Manufacturing	2,629	5.0	135.9	6.5	706.1	12.8
Transportation, Information, Public Utilities	2,122	4.1	118.1	5.7	426.3	7.8
Trade	7,272	13.9	237.7	11.4	491.6	8.9
Service	22,421	43.0	752.2	36.1	2,245.1	40.8
Government	11,452	22.0	611.8	29.4	785.7	14.3
Total	**52,142**		**2,082.5**		**5,497.3**	

Source: 2009 IMPLAN data

P.4 Results

The following sections present the results of the regional economic impact analysis. For each KBRA action, the analysis identifies the project timeframe, in-region spending amount, industry or institutional sector affected, direct and total economic effects of the No Action Alternative and the KBRA relative to the No Action Alternative. The KBRA effects are in addition to the effects of the No Action Alternative. The in-region spending amounts identified in the following paragraphs were provided by project experts in federal and state agencies.

In the results tables, the direct effect is the spending on goods and services in a particular sector, such as construction, or the additional funds to local and state governments to support employee compensation and services. The direct effects are derived from base funding provided by federal agencies and the Revised Appendix C-2 values escalated to 2012 dollars, as appropriate. The secondary effects are the additional employment, income, and output in the regional economy supported by the KBRA actions, as estimated by IMPLAN. The total effects are the sum of direct and secondary effects.

Regional economic effects would occur over a 15-year period. Some actions would be completed in less than 15 years. The Revised Appendix C-2 shows the assumed time period for each action. Because funds are not always spent equally across all years, it is not appropriate to divide the total effect by the number of years to get an annual effect. This analysis only presents the total effects of the 15-year program. The results in the tables are not annual results.

P.4.1 # 1 Coordination and Oversight

Coordination and oversight spending would occur each year for the 15 year KBRA implementation period (2012-2026). The analysis assumes that 90% would be spent in the region and 10% percent would be spent outside the region. The region is the 4-county region. Base funding spent in the region for this action under the No Action Alternative would be $1.35 million over 15 years. Under the KBRA, an additional $0.1 million would be spent within the region over 15 years for this action. State and local governments would implement this action. Table P-6 summarizes regional economic effects of this action for the No Action Alternative and the KBRA relative to the No Action Alternative.

Table P-6. Coordination and Oversight IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	17	$847,000	$1,102,000	2	$74,000	$96,000
Secondary Effects	5	$177,000	$520,000	1	$16,000	$46,000
Total Effects	22	$1,024,000	$1,622,000	3	$90,000	$142,000

P.4.2 Restoration Program

The restoration program includes actions in the Upper and Lower Klamath Basin. Restoration actions have construction components and administration components. Construction components could include fence construction, maintenance, vegetation planting, levee removal, or other activities. It is assumed that much of the construction for restoration programs could be done by local government and contractors. As described above, the Revised Appendix C-2 costs for restoration program actions were inflated to 2012 dollars using the GDP implicit price deflator index. Base funding was identified for most restoration actions, and is indicated below for each action. The 4-county region (Klamath, Siskiyou, Humboldt, and Del Norte Counties) was used for all restoration actions because actions would be implemented and effects would occur in these counties.

P.4.2.1 # 2 Planning and Implementation – Phase 1 and 2 Fishery Restoration Plans

Planning and implementation of the Fishery Restoration Plan would occur in 4 years total or two two-year increments, 2012-2013 and 2020 to 2021. The analysis assumes that 60% would be spent in the region and 40% would be spent outside the region. Base funding spent in the region for this action under the No Action Alternative would be $0.4 million. Under the KBRA, an additional $1.2 million would be spent within the region for this action. State and local governments would implement this action. Table P-7 summarizes regional economic effects of this action for the No Action Alternative and the KBRA relative to the No Action Alternative.

Table P-7. Planning & Implementation Phase I II Restoration Plans IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	5	$264,000	$343,000	15	$760,000	$989,000
Secondary Effects	2	$55,000	$162,000	5	$158,000	$467,000
Total Effects	7	$319,000	$505,000	20	$918,000	$1,456,000

P.4.2.2 # 3 Williamson River Aquatic Habitat Restoration

The Williamson River aquatic habitat restoration would be implemented over a 14-year period (2013–2026). This analysis assumes that almost all of the funds (i.e., 99.6% of the funds) would be spent in the region. Of the in-region spending, 68% would be spent on construction activities and 32% would be spent on administration and management by state and local governments. Base funding spent in the region under the No Action Alternative would be $3.7 million. Under the KBRA, an additional $0.8 million would be spent within the region for this action. Table P-8 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-8. Williamson River Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	34	$1,742,000	$3,516,000	8	$416,000	$838,000
Secondary Effects	16	$636,000	$1,761,000	4	$152,000	$420,000
Total Effects	50	$2,378,000	$5,277,000	12	$568,000	$1,258,000

P.4.2.3 # 4 Sprague River Aquatic Habitat Restoration

The Sprague River aquatic habitat restoration would be implemented over a 15-year period (2012-2026). This action would be conducted similar to the Williamson River aquatic habitat restoration with 99.7% of the expenditure conducted in region and 0.3% of outside region activities. It is assumed that 75% of the in-region spending would be spent on construction and 25% would be spent on administration and management activities by state and local government. Base funding spent in the region under the No Action Alternative would be $11.2 million. Under the KBRA, an additional $41.9 million would be spent within the region spent over a 15-year period for this action. Table P-9 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-9. Sprague River Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	98	$5,045,000	$10,701,000	365	$18,888,000	$40,065,000
Secondary Effects	49	$1,955,000	$5,385,000	181	$7,318,000	$20,163,000
Total Effects	147	$7,000,000	$16,086,000	546	$26,206,000	$60,228,000

P.4.2.4 # 5 Wood River Valley Aquatic Habitat Restoration

The Wood River Valley aquatic habitat restoration would be implemented over a 15-year period (2012–2026). All project dollars would be spent in the region. Of the in-region spending, 88% would be spent on construction activities and the remaining 12% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $3 million. Under the KBRA, an additional $10.7 million would be spent within the region for this action. Table P-10 summarizes regional economic effects of this action under the KBRA relative to the No Action Alternative.

Table P-10. Wood River Valley Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	25	$1,256,000	$2,931,000	88	$4,516,000	$10,540,000
Secondary Effects	14	$545,000	$1,489,000	48	$1,960,000	$5,352,000
Total Effects	39	$1,801,000	$4,420,000	136	$6,476,000	$15,892,000

P.4.2.5 # 6 Williamson Sprague Wood Screening Diversion

This action is a construction project and would occur over a 14-year period from 2013-2026. It is assumed that 70% of total funds would be spent in the region and 30% would be spent outside the region. Of the funds spent in the region, 90% would be spent in the construction sector and 10% would be spent on administration and management by state and local government. There is no base funding identified for this action. Under the KBRA, $2.3 million would be spent within the region for this action. Table P-11 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-11. Williamson Sprague Wood Screening Diversion IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	18	$925,000	$2,191,000
Secondary Effects	0	$0	$0	10	$409,000	$1,115,000
Total Effects	0	$0	$0	28	$1,334,000	$3,306,000

P.4.2.6 # 7 Williamson and Sprague US Forest Service Uplands

This action would be implemented over a 14-year period (2013–2026). It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the in-region spending, 75% would be in the construction sector and 25% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $4.7 million. Under the KBRA, an additional $4.9 million would be spent within the region for this action. Table P-12 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-12. Williamson & Sprague US Forest Service Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	41	$2,105,000	$4,465,000	43	$2,197,000	$4,661,000
Secondary Effects	21	$816,000	$2,247,000	21	$852,000	$2,346,000
Total Effects	62	$2,921,000	$6,712,000	64	$3,049,000	$7,007,000

P.4.2.7 # 8 Upper Klamath Lake Aquatic Habitat Restoration

The Upper Klamath Lake aquatic habitat restoration would be implemented over a 9-year period (2013–2021). All project dollars would be spent in the region. Of the in-region spending, 94% would be spent on construction activities and 6% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $3 million. Under the KBRA, an additional $10.8 million would be spent within the region for this action. Table P-13 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-13. Upper Klamath Lake Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	24	$1,214,000	$2,964,000	85	$4,366,000	$10,667,000
Secondary Effects	14	$556,000	$1,512,000	49	$1,999,000	$5,438,000
Total Effects	38	$1,770,000	$4,476,000	134	$6,365,000	$16,105,000

P.4.2.8 # 9 Screening of Upper Klamath Lake Pumps

This action would occur over a 14-year period from 2013–2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 90% would be spent in the construction sector and 10% would be spent on administration and management by state and local government. There is no base funding identified for this action. Under the KBRA, $0.4 million would be spent within the region for this action. Table P-14 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-14. Screening of Upper Klamath Lake Pumps IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	4	$177,000	$419,000
Secondary Effects	0	$0	$0	2	$78,000	$213,000
Total Effects	0	$0	$0	6	$255,000	$632,000

P.4.2.9 # 10 Upper Klamath Lake Watershed US Forest Service Uplands

This action would occur over a 4-year period from 2018–2021. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 75% would be spent in the construction sector and 25% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $1.1 million. Under the KBRA, an additional $1.6 million would be spent within the region for this action. Table P-15 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-15. Upper Klamath Lake Watershed US Forest Service Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	11	$522,000	$1,106,000	15	$738,000	$1,566,000
Secondary Effects	5	$202,000	$557,000	8	$286,000	$788,000
Total Effects	16	$724,000	$1,663,000	23	$1,024,000	$2,354,000

P.4.2.10 # 11 Keno Impoundment Water Quality Studies and Remediation Actions

This action would occur over a 14-year period from 2013–2026. It is assumed that 55% of total funds would be spent in the region and 45% would be spent outside the region. Of the funds spent in the region, 95% would be spent in the construction sector and 5% would be spent on administration and management by state and local government. There is no base funding identified for this action. Under the KBRA, $29.6 million would be spent within the region for this action. Table P-16 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-16. Keno Impoundment Water Quality Studies & Remediation Actions IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	232	$11,931,000	$29,374,000
Secondary Effects	0	$0	$0	134	$5,512,000	$14,986,000
Total Effects	0	$0	$0	366	$17,443,000	$44,360,000

P.4.2.11 # 12 Keno Impoundment Wetlands Restoration

This action would occur over a 4-year period from 2017–2020. It is assumed that 60% of total funds would be spent in the region and 40% would be spent outside the region. Of the funds spent in the region, 95% would be spent in the construction sector and 5% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $2.3 million. Under the KBRA, an additional $1.1 million would be spent within the region for this action. Table P-17 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-17. Keno Impoundment Wetlands Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	18	$906,000	$2,231,000	8	$406,000	$998,000
Secondary Effects	11	$419,000	$1,138,000	5	$188,000	$510,000
Total Effects	29	$1,325,000	$3,369,000	13	$594,000	$1,508,000

P.4.2.12 # 14 Keno to Iron Gate Upland US Forest Service (Goosenest)

This action would occur over a 14-year period from 2013–2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $0.5 million. Under the KBRA, an additional $0.7 million would be spent within the region for this action. Table P-18 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-18. Keno to Iron Gate Upland US Forest Service (Goosenest) IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	5	$221,000	$486,000	6	$313,000	$688,000
Secondary Effects	3	$90,000	$246,000	4	$127,000	$348,000
Total Effects	8	$311,000	$732,000	10	$440,000	$1,036,000

P.4.2.13 # 15 Keno to Iron Gate Mainstem Restoration

This action would occur over a 9-year period from 2013–2021. It is assumed that 70% of total funds would be spent in the region and 30% would be spent outside the region. Of the funds spent in the region, 60% would be spent in the construction sector and 40% would be spent on administration and management by state and local government. There is no base funding identified for this action. Under the KBRA, $0.9 million would be spent within the region for this action. Table P-19 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-19. Keno to Iron Gate Mainstem Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	9	$462,000	$882,000
Secondary Effects	0	$0	$0	4	$158,000	$439,000
Total Effects	0	$0	$0	13	$620,000	$1,321,000

P.4.2.14 # 16 Keno to Iron Gate Tributaries – Diversion and Riparian

This action would occur over a 3-year period from 2016–2018. It is assumed that 70% of total funds would be spent in the region and 30% would be spent outside the region. Of the funds spent in the region, 60% would be spent in the construction sector and 40% would be spent on administration and management by state and local government. There is no base funding identified for this action. Under the KBRA, $1.1 million would be spent within the region for this action. Table P-20 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-20. Keno to Iron Gate Tributaries - Diversions & Riparian IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	11	$555,000	$1,058,000
Secondary Effects	0	$0	$0	5	$189,000	$527,000
Total Effects	0	$0	$0	16	$744,000	$1,585,000

P.4.2.15 # 17 Shasta River Aquatic Habitat Restoration

This action would occur over a 15-year period from 2012–2026. It is assumed that 70% of total funds would be spent in the region and 30% would be spent outside the region. Of the funds spent in the region, 50% would be spent in the construction sector and 25% would be spent on administration and management by state and local government. An additional 25% would be spent on water acquisitions, which are considered a transfer payment that would not result in regional economic impacts. Base funding spent in the region under the No Action Alternative would be $16.7 million. No additional funding would be spent on this action. Table P-21 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-21. Shasta River Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	113	$5,872,000	$11,740,000	0	$0	$0
Secondary Effects	53	$2,119,000	$5,873,000	0	$0	$0
Total Effects	166	$7,991,000	$17,613,000	0	$0	$0

P.4.2.16 # 18 Shasta River US Forest Service Uplands

Base funding spent in the region under the No Action Alternative would be $0.6 million. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. It is assumed that no additional funding under the KBRA would be spent within the region for this action. Table P-22 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-22. Shasta River US Forest Service Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	6	$265,000	$583,000	0	$0	$0
Secondary Effects	3	$108,000	$295,000	0	$0	$0
Total Effects	9	$373,000	$878,000	0	$0	$0

P.4.2.17 # 19 Scott River Aquatic Habitat Restoration

This action would occur over a 7-year period from 2013–2019. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $18.7 million. It is assumed that no additional funding under the KBRA would be spent within the region for this action. Table P-23 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-23. Scott River Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	159	$8,198,000	$18,032,000	0	$0	$0
Secondary Effects	82	$3,317,000	$9,107,000	0	$0	$0
Total Effects	241	$11,515,000	$27,139,000	0	$0	$0

P.4.2.18 # 20 Scott River US Forest Service Uplands

This action would occur over a 9-year period from 2013–2021. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $0.9 million. Under the KBRA, an additional $0.4 million would be spent within the region for this action. Table P-24 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-24. Scott River US Forest Service Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	9	$420,000	$923,000	4	$202,000	$444,000
Secondary Effects	5	$170,000	$466,000	2	$82,000	$224,000
Total Effects	14	$590,000	$1,389,000	6	$284,000	$668,000

P.4.2.19 # 21 Scott River Private Uplands

This action would occur over a 3-year period from 2014–2016. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $2.1 million. It is assumed that no additional funding under the KBRA would be spent within the region for this action. Table P-25 summarizes regional economic effects of the No Action Alternative.

Table P-25. Scott River Private Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	19	$976,000	$2,130,000	0	$0	$0
Secondary Effects	10	$392,000	$1,075,000	0	$0	$0
Total Effects	29	$1,368,000	$3,205,000	0	$0	$0

P.4.2.20 # 22 Mid Klamath River and Tributaries Aquatic Habitat Restoration

This action would occur over a 14-year period from 2013–2026. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $6.8 million. It is assumed that no additional funding under the KBRA would be spent within the region for this action. Table P-26 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-26. Mid Klamath River & Tributaries (Iron Gate to Weitchpec) Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	58	$2,956,000	$6,502,000	0	$0	$0
Secondary Effects	30	$1,196,000	$3,284,000	0	$0	$0
Total Effects	88	$4,152,000	$9,786,000	0	$0	$0

P.4.2.21 # 23 Mid Klamath Tributaries US Forest Service Uplands

This action would occur over a 14-year period from 2013–2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $3.6 million. Under the KBRA, an additional $4.5 million would be spent within the region for this action. Table P-27 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-27. Mid Klamath Tributaries US Forest Service Upland IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	31	$1,577,000	$3,468,000	39	$2,004,000	$4,406,000
Secondary Effects	16	$638,000	$1,752,000	20	$811,000	$2,225,000
Total Effects	47	$2,215,000	$5,220,000	59	$2,815,000	$6,631,000

P.4.2.22 # 24 Mid Klamath River and Tributaries Private Uplands

This action would occur over a 9-year period from 2013–2021. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $4.2 million. Under the KBRA, an additional $1.9 million would be spent within the region for this action. Table P-28 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-28. Mid Klamath Tributaries Private Upland IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	36	$1,840,000	$4,046,000	16	$827,000	$1,818,000
Secondary Effects	19	$745,000	$2,044,000	9	$335,000	$918,000
Total Effects	55	$2,585,000	$6,090,000	25	$1,162,000	$2,736,000

P.4.2.23 # 25 Lower Klamath River and Tributaries Aquatic Habitat Restoration

This action would occur over a 9-year period from 2013–2021. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $18.2 million. It is assumed that no additional funding under the KBRA would be spent within the region for this action. Table P-29 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-29. Lower Klamath R. & tributaries (Weitchpec to mouth) aquatic habitat restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	154	$7,971,000	$17,531,000	0	$0	$0
Secondary Effects	80	$3,225,000	$8,854,000	0	$0	$0
Total Effects	234	$11,196,000	$26,385,000	0	$0	$0

P.4.2.24 # 26 Lower Klamath River and Tributaries Private Uplands

This action would occur over a 14-year period from 2013–2026. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $9.9 million. Under the KBRA, an additional $25.4 million would be spent within the region for this action. Table P-30 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-30. Lower Klamath Private Uplands IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	84	$4,336,000	$9,536,000	215	$11,136,000	$24,493,000
Secondary Effects	44	$1,754,000	$4,816,000	111	$4,505,000	$12,370,000
Total Effects	128	$6,090,000	$14,352,000	326	$15,641,000	$36,863,000

P.4.2.25 # 27 Salmon River Aquatic Habitat Restoration

This action would occur over a 10-year period from 2013–2022. It is assumed that 100% of total funds would be spent in the region; 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $1.6 million. Under the KBRA, an additional $1.9 million would be spent within the region for this action. Table P-31 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-31. Salmon River Aquatic Habitat Restoration IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	15	$734,000	$1,590,000	17	$858,000	$1,887,000
Secondary Effects	8	$295,000	$810,000	9	$348,000	$953,000
Total Effects	23	$1,029,000	$2,400,000	26	$1,206,000	$2,840,000

P.4.2.26 # 28 Salmon River US Forest Service Uplands

This action would occur over a 14-year period from 2013–2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Base funding spent in the region under the No Action Alternative would be $2.1 million. Under the KBRA, an additional $2.7 million would be spent within the region for this action. Table P-32 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-32. Salmon River US Forest Service Upland IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	18	$912,000	$2,005,000	23	$1,183,000	$2,602,000
Secondary Effects	10	$369,000	$1,013,000	12	$479,000	$1,314,000
Total Effects	28	$1,281,000	$3,018,000	35	$1,662,000	$3,916,000

P.4.3 Reintroduction Program

Actions under the reintroduction program include planning, construction of new facilities, transport, and monitoring and evaluation. There is no base funding identified for the actions in the reintroduction program. The 4-county region was used for all restoration actions. The Revised Appendix C-2 costs for the reintroduction program actions were escalated from 2007 to 2012 dollars using the GDP implicit price deflator index.

P.4.3.1 # 29 Reintroduction Plan

This action would be implemented each year over the 15-year program. This analysis assumes that 100% of the funds would be spent in the region. Agency officials in state and local governments would implement actions. Under the KBRA, $1.6 million would be spent within the region over 15 years for this action. Table P-33 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-33. Reintroduction Plan IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	20	$1,023,000	$1,332,000
Secondary Effects	0	$0	$0	6	$213,000	$628,000
Total Effects	0	$0	$0	26	$1,236,000	$1,960,000

P.4.3.2 # 30 Collection Facility

The Collection Facility includes construction and operation. Funding would be spent over 8 years from 2019 through 2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Under the KBRA, $6 million would be spent within the region over 8 years for this action. Table P-34 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-34. Collection Facility IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	51	$2,634,000	$5,793,000
Secondary Effects	0	$0	$0	27	$1,066,000	$2,926,000
Total Effects	0	$0	$0	78	$3,700,000	$8,719,000

P.4.3.3 # 31 Production Facility

The Production Facility includes construction and operation. Funding would be spent over 10 years from 2017 through 2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Under the KBRA, $6.1 million would be spent within the region over 10 years for this action. Table P-35 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-35. Production Facility IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	52	$2,678,000	$5,890,000
Secondary Effects	0	$0	$0	27	$1,084,000	$2,975,000
Total Effects	0	$0	$0	79	$3,762,000	$8,865,000

P.4.3.4 # 32 Acclimation Facility

The Acclimation Facility includes construction and operation. Funding would be spent over 10 years from 2017 through 2026. It is assumed that 80% of total funds would be spent in the region and 20% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. Under the KBRA, $4.7 million would be spent within the region over 10 years for this action. Table P-36 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-36. Acclimation Facility IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	40	$2,063,000	$4,536,000
Secondary Effects	0	$0	$0	21	$835,000	$2,291,000
Total Effects	0	$0	$0	61	$2,898,000	$6,827,000

P.4.3.5 # 33 Transport

Transport activities would occur annually for 8 years from 2019 through 2026. This analysis assumes that 100% of the funds would be spent in the region. Agency officials in state and local governments would implement actions. Under the KBRA, $0.8 million would be spent within the region over 8 years for this action. Table P-37 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-37. Transport IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	10	$519,000	$675,000
Secondary Effects	0	$0	$0	3	$108,000	$319,000
Total Effects	0	$0	$0	13	$627,000	$994,000

P.4.3.6 # 34 Monitoring and Evaluation – Oregon

Monitoring and evaluation would occur each year for the 15 year KBRA implementation period (2012–2026). This analysis assumes that 90% of the funds would be spent in the region and 10% would be spent out of region. Agency officials in state and local governments in the region would implement actions. Under the KBRA, $29.8 million would be spent within the region over 15 years for this action. Table P-38 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-38. Monitoring and Evaluation – Oregon IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	356	$18,709,000	$24,343,000
Secondary Effects	0	$0	$0	105	$3,892,000	$11,485,000
Total Effects	0	$0	$0	461	$22,601,000	$35,828,000

P.4.3.7 # 35 Monitoring and Evaluation – California

Monitoring and evaluation would occur each year for the 15 year KBRA implementation period (2012–2026). This analysis assumes that 100% of the funds would be spent in the region. Agency officials in state and local governments would implement actions. Under the KBRA, $2.9 million would be spent within the region over 15 years for this action. Table P-39 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-39. Monitoring and Evaluation – California IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	36	$1,879,000	$2,445,000
Secondary Effects	0	$0	$0	11	$391,000	$1,154,000
Total Effects	0	$0	$0	47	$2,270,000	$3,599,000

P.4.3.8 # 36 New Hatchery

The New Hatchery includes construction and operation. Funding would be spent over 8 years from 2014 through 2021. It is assumed that 60% of total funds would be spent in the region and 40% would be spent outside the region. Of the funds spent in the region, 80% would be spent in the construction sector and 20% would be spent on administration and management by state and local government. There is no base funding for this action. Under the KBRA, $5.5 million would be spent within the region over 8 years for this action. Table P-40 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-40. New Hatchery (IGD or Fall Creek) IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	47	$2,429,000	$5,343,000
Secondary Effects	0	$0	$0	25	$983,000	$2,698,000
Total Effects	0	$0	$0	72	$3,412,000	$8,041,000

P.4.4 Monitoring Program

The monitoring program includes actions in the Upper and Lower Klamath Basin. For the most part, the majority of funds would be spent in the 4-county region and would be implemented by state and local government. Some actions in the Upper Basin would rely on environmental professionals in local firms. Monitoring costs in the Revised Appendix C-2 were inflated to 2012 dollars using the GDP implicit price deflator. Base funding was identified for most monitoring actions, which is defined below for each action.

P.4.4.1 # 37 Adult Salmonids

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $7.4 million. Under the KBRA, an additional $9.9 million would be spent within the region. Table P-41 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-41. Adult Salmonids IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	89	$4,642,000	$6,040,000	119	$6,243,000	$8,122,000
Secondary Effects	26	$966,000	$2,850,000	35	$1,299,000	$3,832,000
Total Effects	115	$5,608,000	$8,890,000	154	$7,542,000	$11,954,000

P.4.4.2 # 38 Juvenile Salmonids

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $4.1 million. Under the KBRA, an additional $14.6 million would be spent within the region. Table P-42 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-42. Juvenile Salmonids IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	49	$2,578,000	$3,355,000	175	$9,177,000	$11,940,000
Secondary Effects	15	$537,000	$1,583,000	52	$1,909,000	$5,633,000
Total Effects	64	$3,115,000	$4,938,000	227	$11,086,000	$17,573,000

P.4.4.3 # 39 Genetics Otolith

This action would occur over 14 years (2013–2026). This analysis assumes that 50% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $2.1 million. It is assumed that no additional funding under the KBRA would be spent within the region. Table P-43 summarizes regional economic effects of the No Action Alternative.

Table P-43. Genetics Otololith IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	27	$1,424,000	$1,848,000	0	$0	$0
Secondary Effects	8	$296,000	$871,000	0	$0	$0
Total Effects	35	$1,720,000	$2,719,000	0	$0	$0

P.4.4.4 # 40 Hatchery Tagging

Base funding spent in the region under the No Action Alternative would be $0.3 million. This analysis assumes that 100% of the funds would be spent in the region. State and local governments would implement monitoring. It is assumed that no additional funding under the KBRA would be spent within the region. Table P-44 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-44. Hatchery Tagging IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	4	$198,000	$258,000	0	$0	$0
Secondary Effects	2	$42,000	$122,000	0	$0	$0
Total Effects	6	$240,000	$380,000	0	$0	$0

P.4.4.5 # 41 Disease

This action would occur over 14 years (2013–2026). This analysis assumes that 70% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $0.3 million. Under the KBRA, an additional $5.2 million would be spent within the region. Table P-45 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-45. Disease IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	4	$199,000	$258,000	63	$3,271,000	$4,256,000
Secondary Effects	2	$42,000	$122,000	19	$681,000	$2,008,000
Total Effects	6	$241,000	$380,000	82	$3,952,000	$6,264,000

P.4.4.6 # 42 Green Sturgeon

This action would occur over 14 years (2013–2026). This analysis assumes that 95% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $2.5 million. It is assumed that no additional funding under the KBRA would be spent within the region. Table P-46 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-46. Green Sturgeon IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	30	$1,556,000	$2,024,000	0	$0	$0
Secondary Effects	9	$324,000	$955,000	0	$0	$0
Total Effects	39	$1,880,000	$2,979,000	0	$0	$0

P.4.4.7 # 43 Lamprey

This action would occur over 14 years (2013–2026). This analysis assumes that 95% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $0.4 million. Under the KBRA, an additional $1.8 million would be spent within the region. Table P-47 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-47. Lamprey IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	5	$233,000	$303,000	22	$1,153,000	$1,500,000
Secondary Effects	2	$49,000	$143,000	7	$240,000	$708,000
Total Effects	7	$282,000	$446,000	29	$1,393,000	$2,208,000

P.4.4.8 # 44 Geomorphology

This action would occur over 9 years (2017–2025). This analysis assumes that 60% of the funds would be spent in the region. State and local governments would implement monitoring. Base funding spent in the region under the No Action Alternative would be $0.1 million. Under the KBRA, an additional $1.6 million would be spent within the region. Table P-48 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-48. Geomorphology IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	2	$96,000	$125,000	20	$1,009,000	$1,313,000
Secondary Effects	1	$20,000	$59,000	6	$210,000	$620,000
Total Effects	3	$116,000	$184,000	26	$1,219,000	$1,933,000

P.4.4.9 # 45 Habitat Monitoring

This action would occur over 14 years (2013–2026). This analysis assumes that 90% of the funds would be spent in the region. State and local governments would implement monitoring. There is no base funding identified for habitat monitoring. Under the KBRA, $2.6 million would be spent within the region. Table P-49 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-49. Habitat Monitoring IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	32	$1,657,000	$2,156,000
Secondary Effects	0	$0	$0	10	$345,000	$1,017,000
Total Effects	0	$0	$0	42	$2,002,000	$3,173,000

P.4.4.10 # 46 Water Quality

This action would occur each year for the 15 year KBRA implementation period (2012-2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $1.5 million. Under the KBRA, an additional $0.8 million would be spent within the region. Table P-50 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-50. Water Quality IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	19	$945,000	$1,318,000	1	$52,000	$73,000
Secondary Effects	7	$231,000	$667,000	1	$13,000	$37,000
Total Effects	26	$1,176,000	$1,985,000	2	$65,000	$110,000

P.4.4.11 # 47 Upper Klamath Lake Bloom Dynamics

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $1.5 million. It is assumed that no additional funding under the KBRA would be spent within the region. Table P-51 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-51. Upper Klamath Lake Bloom Dynamics IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	19	$945,000	$1,318,000	0	$0	$0
Secondary Effects	7	$231,000	$667,000	0	$0	$0
Total Effects	26	$1,176,000	$1,985,000	0	$0	$0

P.4.4.12 # 48 Upper Klamath Lake Water Quality/Phytoplankton/Zooplankton

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $2 million. Under the KBRA, an additional $4.1 million would be spent within the region. Table P-52 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-52. Upper Klamath Lake Water Quality/Phytoplankton/Zooplankton IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	25	$1,236,000	$1,723,000	51	$2,535,000	$3,535,000
Secondary Effects	9	$301,000	$872,000	17	$618,000	$1,789,000
Total Effects	34	$1,537,000	$2,595,000	68	$3,153,000	$5,324,000

P.4.4.13 # 49 Upper Klamath Lake Internal Load/Bloom Dynamics

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $1.8 million. Under the KBRA, an additional $1.2 million would be spent within the region. Table P-53 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-53. Upper Klamath Lake Internal Load/Bloom Dynamics IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	22	$1,101,000	$1,536,000	16	$761,000	$1,062,000
Secondary Effects	8	$269,000	$777,000	5	$186,000	$537,000
Total Effects	30	$1,370,000	$2,313,000	21	$947,000	$1,599,000

P.4.4.14 # 50 Upper Klamath Lake External Nutrient Loading

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $60,000. Under the KBRA, an additional $3.8 million would be spent within the region. Table P-54 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-54. Upper Klamath Lake External Nutrient Loading IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	1	$37,000	$52,000	48	$2,374,000	$3,310,000
Secondary Effects	1	$9,000	$26,000	16	$578,000	$1,675,000
Total Effects	2	$46,000	$78,000	64	$2,952,000	$4,985,000

P.4.4.15 # 51 Upper Klamath Lake Analysis of Long-Term Data Sets

This action would occur in 2 years (2019 and 2024). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. There is no base funding identified for habitat monitoring. Under the KBRA, $0.6 million would be spent within the region. Table P-55 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-55. Upper Klamath Lake analysis of long-term data sets IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	8	$399,000	$556,000
Secondary Effects	0	$0	$0	3	$98,000	$282,000
Total Effects	0	$0	$0	11	$497,000	$838,000

P.4.4.16 # 52 Upper Klamath Lake Listed Suckers

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $8.9 million. Under the KBRA, an additional $4.3 million would be spent within the region. Table P-56 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-56. Upper Klamath Lake Listed Suckers IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	110	$5,496,000	$7,664,000	53	$2,649,000	$3,694,000
Secondary Effects	36	$1,338,000	$3,878,000	18	$645,000	$1,870,000
Total Effects	146	$6,834,000	$11,542,000	71	$3,294,000	$5,564,000

P.4.4.17 # 53 Tributaries Water Quality/Nutrients/Sediment

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. There is no base funding identified for this action. Under the KBRA, $4.7 million would be spent within the region. Table P-57 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-57. Tributaries Water Quality/Nutrients/Sediment IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	58	$2,886,000	$4,024,000
Secondary Effects	0	$0	$0	19	$703,000	$2,037,000
Total Effects	0	$0	$0	77	$3,589,000	$6,061,000

P.4.4.18 # 54 Tributaries Geomorphology/Riparian Vegetation

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. There is no base funding identified for this action. Under the KBRA, $3.6 million would be spent within the region. Table P-58 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-58. Tributaries Geomorphology/Riparian Vegetation IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	45	$2,225,000	$3,102,000
Secondary Effects	0	$0	$0	15	$542,000	$1,570,000
Total Effects	0	$0	$0	60	$2,767,000	$4,672,000

P.4.4.19 # 55 Tributaries Physical Habitat

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. There is no base funding identified for this action. Under the KBRA, $3.2 million would be spent within the region. Table P-59 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-59. Tributaries Physical Habitat IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	40	$1,983,000	$2,765,000
Secondary Effects	0	$0	$0	13	$483,000	$1,399,000
Total Effects	0	$0	$0	53	$2,466,000	$4,164,000

P.4.4.20 # 56 Tributaries Listed Suckers

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $0.9 million. Under the KBRA, an additional $4.7 million would be spent within the region. Table P-60 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-60. Tributaries Listed Suckers IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	12	$569,000	$794,000	58	$2,922,000	$4,074,000
Secondary Effects	4	$139,000	$402,000	19	$712,000	$2,062,000
Total Effects	16	$708,000	$1,196,000	77	$3,634,000	$6,136,000

P.4.4.21 # 57 Keno Impoundment Water Quality/Algae/Nutrients

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. Base funding spent in the region under the No Action Alternative would be $70,000. Under the KBRA, an additional $6 million would be spent within the region. Table P-61 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-61. Keno Impoundment Water Quality/Algae/Nutrients IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	1	$43,000	$60,000	74	$3,700,000	$5,159,000
Secondary Effects	1	$11,000	$31,000	25	$901,000	$2,611,000
Total Effects	2	$54,000	$91,000	99	$4,601,000	$7,770,000

P.4.4.22 # 58 Keno Impoundment to Tributaries: Meteorology

This action would occur over 14 years (2013–2026). This analysis assumes that 100% of the funds would be spent in the region. 80% would be allocated to state and local governments to implement monitoring and 20% would go to the environmental and other technical consulting sector. There is no base funding identified for this action. Under the KBRA, $3 million would be spent within the region. Table P-62 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-62. Keno Impoundment to Tributaries: Meteorology (weather stations) IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	37	$1,862,000	$2,597,000
Secondary Effects	0	$0	$0	13	$454,000	$1,314,000
Total Effects	0	$0	$0	50	$2,316,000	$3,911,000

P.4.5 Water Resources Program

This section presents regional economic effects of implementing the water resources programs in the KBRA. As noted above, some water resource program actions that could affect irrigated agriculture and wildlife refuges through water acquisitions or on-farm pumping costs were evaluated separately. The Irrigated Agriculture Economics Technical Report and Refuge Recreation Technical Report describes the regional economic effects of these actions. The Revised Appendix C-2 costs for the water resource program actions were escalated from 2007 to 2012 dollars using the GDP implicit price deflator index. The economic region for the actions varies depending on where the action would occur. The sections below indicate whether the 4-county or 3-county region was used. Water resources program actions analyzed below do not have base funding.

P.4.5.1 # 61 Data Analysis and Evaluation for Provision to TAT

This action would occur over 9 years (2013–2021) in the 4-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments in the region would implement actions. Under the KBRA, $168,000 would be spent within the region over 9 years for this action. Table P-63 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-63. Data Analysis and Evaluation for Provision to TAT IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	2	$104,000	$133,000
Secondary Effects	0	$0	$0	1	$22,000	$64,000
Total Effects	0	$0	$0	3	$126,000	$197,000

P.4.5.2 # 62 Development of Predictive Techniques

This action would occur over 9 years (2013–2021) in the 4-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments in the region would implement actions. Under the KBRA, $391,000 would be spent within the region over 9 years for this action. Table P-64 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-64. Development of Predictive Techniques IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	5	$246,000	$320,000
Secondary Effects	0	$0	$0	2	$52,000	$151,000
Total Effects	0	$0	$0	7	$298,000	$471,000

P.4.5.3 # 64 Klamath Basin Wildlife Refuges: Walking Wetland Construction

Funding would occur each year for the 15 year KBRA implementation period (2012-2026) for this action. This action would occur in the 3-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments would implement actions. Under the KBRA, $2.5 million would be spent within the region. Table P-65 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-65. Klamath Basin Wildlife Refuges: Walking Wetland Construction IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	26	$1,486,000	$2,500,000
Secondary Effects	0	$0	$0	14	$469,000	$1,299,000
Total Effects	0	$0	$0	40	$1,955,000	$3,799,000

P.4.5.4 # 74 Energy Efficiency and Renewable Resources

This action includes funds to construct renewable energy projects to stabilize power costs for irrigation purposes. It is assumed that at least one project could be identified and constructed in the 3-county region that serves Reclamation's Klamath Project; therefore, about 10% of the total spending would stay in the region and 90% would be outside the region. This action would be implemented in 4 years, from 2013 through 2016. Under the KBRA, $4.4 million would be spent within the region. Table P-66 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-66. Energy Efficiency and Renewable Resources IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	36	$1,608,000	$4,402,000
Secondary Effects	0	$0	$0	18	$670,000	$1,809,000
Total Effects	0	$0	$0	54	$2,278,000	$6,211,000

P.4.5.5 # 76 Upper Klamath Lake Wetland Restoration: Agency/Barnes

This action would occur over 5 years, 2016 through 2020, in the 4-county region. This analysis assumes that 90% of the funds would be spent in the region and 10% would be spent out of region. All in-region funds would be spent in the construction sector. Under the KBRA, $2.7 million would be spent within the region over 5 years for this action. Table P-67 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-67. Upper Klamath Lake Wetlands Restoration: Agency/Barnes IMPLAN Model Results

	No Alternatives Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	21	$1,062,000	$2,717,000
Secondary Effects	0	$0	$0	13	$514,000	$1,391,000
Total Effects	0	$0	$0	34	$1,576,000	$4,108,000

P.4.5.6 # 77 Upper Klamath Lake Wetland Restoration: Wood River

This action would occur over 5 years, 2017 through 2021, in the 4-county region. This analysis assumes that 90% of the funds would be spent in the region and 10% would be spent out of region. All in-region funds would be spent in the construction sector. Under the KBRA, $2.7 million would be spent within the region over 10 years for this action. Table P-68 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-68. Upper Klamath Lake Wetlands Restoration: Wood River IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	21	$1,062,000	$2,717,000
Secondary Effects	0	$0	$0	13	$514,000	$1,391,000
Total Effects	0	$0	$0	34	$1,576,000	$4,108,000

P.4.5.7 # 85 Real Time Water Management: Water Flow Monitoring

This action would occur each year for the 15 year KBRA implementation period (2012-2026) in the 4-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments in the region would implement actions. Under the KBRA, $3.2 million would be spent within the region over 15 years for this action. Table P-69 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-69. Real Time Water Management: Water Flow Monitoring and Gauges IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	39	$2,032,000	$2,644,000
Secondary Effects	0	$0	$0	12	$423,000	$1,248,000
Total Effects	0	$0	$0	51	$2,455,000	$3,892,000

P.4.5.8 # 87 Adaptive Management: Science and Analysis

This action would occur each year for the 10 year KBRA implementation period (2012-2021) in the 4-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments in the region would implement actions. Under the KBRA, $1.1 million would be spent within the region over 10 years for this action. Table P-70 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-70. Adaptive Management: Science and Analysis IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	13	$682,000	$888,000
Secondary Effects	0	$0	$0	4	$142,000	$419,000
Total Effects	0	$0	$0	17	$824,000	$1,307,000

P.4.5.9 # 88 Real Time Management: Calibration and Improvement

This action would occur two years (2013 and 2019) in the 4-county region. This analysis assumes that 100% of the funds would be spent in the region. State and local governments in the region would implement actions. Under the KBRA, $109,000 would be spent within the region for this action. Table P-71 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-71. Real Time Management: Calibration and improvements to KLAMSIM or other modeling and predictions IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	2	$69,000	$89,000
Secondary Effects	0	$0	$0	1	$15,000	$42,000
Total Effects	0	$0	$0	3	$84,000	$131,000

P.4.6 Regulatory Assurances

There are four actions defined as regulatory assurances; only two are evaluated below. The KBRA identified actions to develop laws for California and Oregon. The states would be responsible for implementing these actions. These actions would provide some local employment to state government staff in the region. Much of the work would occur by state workers outside of the region, which would not affect the regional economy. There is no base funding identified for the actions. The Revised Appendix C-2 costs have been inflated to 2012 dollars using the GDP implicit price deflator index.

P.4.6.1 # 90 Keno Impoundment Klamath Irrigation Project Screening

This action would occur in 4 years (2017–2020). This action is assumed to occur in the 4-county region. This analysis assumes that 20% of the funds would be spent in the region and 80% would be spent out of region. All in-region expenditures would be in the construction sector. Under the KBRA, $5.5 million would be spent within the region for this action. Table P-72 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-72. Keno Impoundment KIP Screening IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	42	$2,137,000	$5,470,000
Secondary Effects	0	$0	$0	25	$1,033,000	$2,800,000
Total Effects	0	$0	$0	67	$3,170,000	$8,270,000

P.4.6.2 # 91 Federal General Conservation Plans/Habitat Conservation Plans

This action would occur over 8 years (2015–2022). This action is assumed to occur in the 4-county region. This analysis assumes that 85% of the funds would be spent in the region and 15% would be spent out of region. State and local governments in the region would implement actions within the region. Under the KBRA, $5.1 million would be spent within the region over 8 years for this action. Table P-73 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-73. Federal GCP/HCP IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	61	$3,188,000	$4,148,000
Secondary Effects	0	$0	$0	18	$663,000	$1,957,000
Total Effects	0	$0	$0	79	$3,851,000	$6,105,000

P.4.7 Counties Program

There are two KBRA actions with funding under the counties program. The first action is funding to Klamath County of $3.2 million in 2016. The second action is funding to Siskiyou County of $20 million in 2018. There is no federal funding for these actions, so they are not included in the Revised Appendix C-2. These costs are based on the original Appendix C2 and were assumed to be nominal dollars and not escalated. The respective states, Oregon and California, would fund these actions. At this time, it is difficult to predict how counties would use funds within the region; therefore, effects are not quantified. Funds would likely be spent across various sectors of the economy. Spending is assumed to occur locally and would substantially increase income, employment, and output in the region. There would be positive regional economic benefits associated with implementing these actions. Section 3.15, Socioeconomics, of the EIS/EIR provides a qualitative analysis of these actions.

P.4.8 Tribal Program

The tribal program includes fisheries management, conservation management, and economic development programs for the Karuk, Klamath, and Yurok Tribes. For these actions, money would be given to tribal governments to implement fisheries, conservation, and economic programs. This analysis assumes that the tribes would spend KBRA dollars within the government to implement the actions. There is base funding identified for the fisheries and conservation management actions. There is no base funding for the economic development actions. It is assumed that all funds going to tribes would be spent within the region. Funds in the Revised Appendix C-2 were assumed to be nominal dollars and were not escalated.

IMPLAN does not specify a tribal government sector. Similar to local and state governments, tribal governments spend money on a variety of functions including employee payroll, planning, research, legal, financial and cultural activities, natural resources work, economic development and many others. This analysis assumes that tribal government spending would be similar to state and local governments and uses the

State and Local Government Non-Education spending pattern to evaluate effects of the tribal program. Actions were assumed to occur in the 4-county region.

The tribal program also includes an action to purchase the Mazama Forest lands for the Klamath Tribes. There is no base funding for this action. The Mazama Forest Project would be a transfer of funds from the government to a private land owner, then the land would be given to the Klamath Tribes. The Klamath Tribes would benefit from the purchased land. At this time, it is not possible to identify direct effects of the Klamath Tribes use of the forest lands. Therefore, regional economic effects are not quantified for this action. It is assumed that once the Klamath Tribes own and use the land beneficially, and there would be positive economic effects to the region.

P.4.8.1 # 100 Fisheries Management Karuk

This action would occur over 15 years (2012–2026). This analysis assumes that 100% of the funds would be spent in the region in Siskiyou County. Of the in-region spending, 100% would be spent on tribal salaries. Base funding spent in the region under the No Action Alternative would be $10.4 million. Under the KBRA, $4 million would be spent within the region over 15 years for this action. Table P-74 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-74. Fisheries Management Karuk IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	138	$6,396,000	$8,276,000	54	$2,464,000	$3,188,000
Secondary Effects	31	$1,109,000	$3,367,000	12	$427,000	$1,297,000
Total Effects	169	$7,505,000	$11,643,000	66	$2,891,000	$4,485,000

P.4.8.2 # 101 Fisheries Management Klamath Tribes

This action would occur over 15 years (2012–2026). This analysis assumes that 100% of the funds would be spent in Klamath County. Of the in-region spending, 5% would be spent on construction activities and 95% would be spent on tribal salaries. Base funding spent in the region under the No Action Alternative would be $8.9 million. Under the KBRA, $5.5 million would be spent within the region over 15 years for this action. Table P-75 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-75. Fisheries Management Klamath IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	89	$4,905,000	$6,813,000	55	$3,000,000	$4,167,000
Secondary Effects	29	$1,030,000	$2,904,000	18	$630,000	$1,776,000
Total Effects	118	$5,935,000	$9,717,000	73	$3,630,000	$5,943,000

P.4.8.3 # 102 Fisheries Management Yurok Tribe

This action would occur over 15 years (2012–2026). This analysis assumes that 100% of the funds would be spent in Humboldt County. Of the in-region spending, 16% would be spent on construction activities and 74% would be spent on tribal salaries and the remaining 10% would be spent on professional and engineering services. Base funding spent in the region under the No Action Alternative would be $8.9 million. Under the KBRA, $5.5 million would be spent within the region over 15 years for this action. Table P-76 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-76. Fisheries Management Yurok IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	103	$5,323,000	$7,852,000	65	$3,331,000	$4,913,000
Secondary Effects	38	$1,469,000	$4,256,000	24	$921,000	$2,668,000
Total Effects	141	$6,792,000	$12,108,000	89	$4,252,000	$7,581,000

P.4.8.4 # 104 Conservation Management Karuk Tribe

This action would occur over 15 years (2012–2026). This analysis assumes that 100% of the funds would be spent in Siskiyou County. Of the in-region spending, 100% would be spent on tribal salaries. Base funding spent in the region under the No Action Alternative would be $4.2 million. Under the KBRA, $3 million would be spent within the region over 15 years for this action. Table P-77 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-77. Conservation Management Karuk IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	56	$2,567,000	$3,321,000	41	$1,864,000	$2,412,000
Secondary Effects	12	$445,000	$1,351,000	9	$323,000	$981,000
Total Effects	68	$3,012,000	$4,672,000	50	$2,187,000	$3,393,000

P.4.8.5 # 105 Conservation Management Klamath Tribes

This action would occur over 15 years (2012–2026). This analysis assumes that 100% of the funds would be spent in Klamath County. Of the in-region spending, 5% would be spent on construction activities and 95% would be spent on tribal salaries. Base funding spent in the region under the No Action Alternative would be $4.2 million. Under the KBRA, $3 million would be spent within the region over 15 years for this action. Table P-78 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-78. Conservation Management Klamath IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	42	$2,290,000	$3,181,000	31	$1,663,000	$2,311,000
Secondary Effects	14	$481,000	$1,356,000	10	$350,000	$985,000
Total Effects	56	$2,771,000	$4,537,000	41	$2,013,000	$3,296,000

P.4.8.6 # 106 Conservation Management Yurok Tribe

This action would occur over 15 years (2012–2026). This analysis assumes that funds would be spent in Humboldt County and Del Norte County. Of the in-region spending, 18% would be spent on construction activities and 72% would be spent on tribal salaries and the remaining 10% would be spent on professional and engineering services. Base funding spent in the region under the No Action Alternative would be $4.2 million. Under the KBRA, $3 million would be spent within the region over 15 years for this action. Table P-79 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-79. Conservation Management Yurok IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	49	$2,490,000	$3,706,000	35	$1,808,000	$2,691,000
Secondary Effects	18	$698,000	$2,018,000	14	$507,000	$1,465,000
Total Effects	67	$3,188,000	$5,724,000	49	$2,315,000	$4,156,000

P.4.8.7 # 108 Economic Development Karuk Tribe

This action would occur over 1 year (2013). 100% of the funds would be spent in the region on professional and engineering services. It is assumed professional and engineering services would be available in the 4-county region. Under the KBRA, $0.2 million would be spent within the region for this action. Table P-80 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-80. Economic Development Study Karuk IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	4	$140,000	$250,000
Secondary Effects	0	$0	$0	2	$57,000	$156,000
Total Effects	0	$0	$0	6	$197,000	$406,000

P.4.8.8 # 109 Economic Development Klamath Tribes

This action would occur over 1 year (2013). 100% of the funds would be spent in the region on professional and engineering services. It is assumed professional and engineering services would be available in the 4-county region. Under the KBRA, $0.2 million would be spent within the region for this action. Table P-81 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-81. Economic Development Study Klamath Tribes IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	4	$140,000	$250,000
Secondary Effects	0	$0	$0	2	$57,000	$156,000
Total Effects	0	$0	$0	6	$197,000	$406,000

P.4.8.9 # 110 Economic Development Yurok

This action would occur over 1 year (2013). 100% of the funds would be spent in the region on professional and engineering services. It is assumed professional and engineering services would be available in the 4-county region. Under the KBRA, $0.2 million would be spent within the region for this action. Table P-82 summarizes regional economic effects of this action under KBRA relative to the No Action Alternative.

Table P-82. Economic Development Study Yurok IMPLAN Model Results

	No Action Alternative (Base Funding)			KBRA Relative to No Action Alternative (over and above Base Funding)		
	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)	Employment (Jobs)	Labor Income (Dollars)	Output (Dollars)
Direct Effects	0	$0	$0	4	$140,000	$250,000
Secondary Effects	0	$0	$0	2	$57,000	$156,000
Total Effects	0	$0	$0	6	$197,000	$406,000

P.4.9 Regional Economic Effects Summary

Table P-83 summarizes regional economic effects of each action under base funding for the No Action Alternative and the KBRA for the Facilities Removal Alternatives relative to the No Action Alternative. The effects of the KBRA are in addition to the effects of base funding under the No Action Alternative. The total effects shown in Table P-83 would occur over a 15-year period from 2012 through 2026; they are not annual effects. Effects per year would vary based on the implementation schedule identified in Revised Appendix C-2.

Base funding of $196.2 million over 15 years under the No Action Alternative would support 2,629 jobs, $125.4 million in labor income, and $253.8 million in economic output within the 4-county region (Klamath, Siskiyou, Del Norte, and Humboldt Counties). There is no based funding associated with projects in the 3-county region. Implementation of the KBRA under the Facilities Removal Alternatives would support an additional 4,598 jobs, $218.8 million in labor income, and $439.6 million in economic output relative to the No Action Alternative within the 4-county region (Klamath, Siskiyou, Del Norte, and Humboldt Counties) and 94 jobs, $4.2 million in labor income, and $10 million in economic output relative to the No Action Alternative within the 3-county region (Klamath, Siskiyou and Modoc Counties).

Table P-83. KBRA Regional Economic Effects Summary (2012 dollars)

#	KBRA Action	Action span (years)	Total Effects[1] of Base Funding			Total Effects[1] of KBRA Funding (over and above Base Funding)		
			Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]	Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]
1	Coordination and Oversight	15	22	$1,024	$1,622	3	$90	$142
2	Planning & Implementation - Phase I and II Restoration Plans	4	7	$319	$505	20	$918	$1,456
3	Williamson River aquatic habitat restoration	14	50	$2,378	$5,277	12	$568	$1,258
4	Sprague River aquatic habitat restoration	15	147	$7,000	$16,086	546	$26,206	$60,228
5	Wood River Valley aquatic habitat restoration	15	39	$1,801	$4,420	136	$6,476	$15,892
6	Williamson Sprague Wood Screening Diversion	14	0	$0	$0	28	$1,334	$3,306
9	Screening of UKL pumps	14	0	$0	$0	6	$255	$632
7	Williamson & Sprague USFS uplands	14	62	$2,921	$6,712	64	$3,049	$7,007
8	Upper Klamath Lake aquatic habitat restoration	9	38	$1,770	$4,476	134	$6,365	$16,105
10	UKL watershed USFS uplands	4	16	$724	$1,663	23	$1,024	$2,354
11	Keno Impoundment water quality studies & remediation actions	14	0	$0	$0	366	$17,443	$44,360
12	Keno Impoundment wetlands restoration	4	29	$1,325	$3,369	13	$594	$1,508
13	Keno to Iron Gate upland private & BLM	No funding identified in C2						
14	Keno to Iron Gate upland USFS (Goosenest)	14	8	$311	$732	10	$440	$1,036
15	Keno to Iron Gate mainstem restoration	9	0	$0	$0	13	$620	$1,321
16	Keno to Iron Gate tributaries - diversions & riparian	3	0	$0	$0	16	$744	$1,585
17	Shasta River aquatic habitat restoration	15	166	$7,991	$17,613	0	$0	$0
18	Shasta River USFS uplands	0	9	$373	$878	0	$0	$0
20	Scott River USFS uplands	9	14	$590	$1,389	6	$284	$668
23	Mid Klamath tributaries USFS upland	14	47	$2,215	$5,220	59	$2,815	$6,631
28	Salmon River USFS upland	14	28	$1,281	$3,018	35	$1,662	$3,916

Table P-83. KBRA Regional Economic Effects Summary (2012 dollars)

#	KBRA Action	Action span (years)	Total Effects[1] of Base Funding			Total Effects[1] of KBRA Funding (over and above Base Funding)		
			Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]	Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]
19	Scott River aquatic habitat restoration	7	241	$11,515	$27,139	0	$0	$0
21	Scott River private uplands	3	29	$1,368	$3,205	0	$0	$0
24	Mid Klamath tributaries private upland	9	55	$2,585	$6,090	25	$1,162	$2,736
26	Lower Klamath private uplands	14	128	$6,090	$14,352	326	$15,641	$36,863
22	Mid Klamath River & tributaries (Iron Gate to Weitchpec) aquatic habitat restoration	14	88	$4,152	$9,786	0	$0	$0
25	Lower Klamath River & tributaries (Weitchpec to mouth) aquatic habitat restoration	9	234	$11,196	$26,385	0	$0	$0
27	Salmon River aquatic habitat restoration	10	23	$1,029	$2,400	26	$1,206	$2,840
29	Reintroduction Plan	15	0	$0	$0	26	$1,236	$1,960
30	Collection Facility	8	0	$0	$0	78	$3,700	$8,719
31	Production Facility	10	0	$0	$0	79	$3,762	$8,865
32	Acclimation Facility	10	0	$0	$0	61	$2,898	$6,827
33	Transport	8	0	$0	$0	13	$627	$994
34	Monitoring and Evaluation – Oregon	15	0	$0	$0	461	$22,601	$35,828
35	Monitoring and Evaluation – California	15	0	$0	$0	47	$2,270	$3,599
36	New Hatchery (IGD or Fall Creek)	8	0	$0	$0	72	$3,412	$8,041
37	Adult Salmonids	14	115	$5,608	$8,890	154	$7,542	$11,954
38	Juvenile Salmonids	14	64	$3,115	$4,938	227	$11,086	$17,573
39	Genetics Otololith	14	35	$1,720	$2,719	0	$0	$0
40	Hatchery Tagging	0	6	$240	$380	0	$0	$0
41	Disease	14	6	$241	$380	82	$3,952	$6,264
42	Green Sturgeon	14	39	$1,880	$2,979	0	$0	$0
43	Lamprey	14	7	$282	$446	29	$1,393	$2,208
44	Geomorphology	9	3	$116	$184	26	$1,219	$1,933
45	Habitat Monitoring	14	0	$0	$0	42	$2,002	$3,173
46	Water Quality	15	26	$1,176	$1,985	2	$65	$110
47	UKL bloom dynamics	14	26	$1,176	$1,985	0	$0	$0
48	UKL water quality/ phytoplankton/ zooplankton	14	34	$1,537	$2,595	68	$3,153	$5,324
49	UKL internal load/ bloom dynamics	14	30	$1,370	$2,313	21	$947	$1,599
50	UKL external nutrient loading	14	2	$46	$78	64	$2,952	$4,985

Table P-83. KBRA Regional Economic Effects Summary (2012 dollars)

#	KBRA Action	Action span (years)	Total Effects[1] of Base Funding			Total Effects[1] of KBRA Funding (over and above Base Funding)		
			Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]	Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]
51	UKL analysis of long-term data sets	3	0	$0	$0	11	$497	$838
52	UKL listed suckers	14	146	$6,834	$11,542	71	$3,294	$5,564
53	Tributaries water quality/ nutrients/sediment	14	0	$0	$0	77	$3,589	$6,061
54	Tributaries geomorphology/ riparian vegetation	14	0	$0	$0	60	$2,767	$4,672
55	Tributaries physical habitat	14	0	$0	$0	53	$2,466	$4,164
56	Tributaries listed suckers	14	16	$708	$1,196	77	$3,634	$6,136
57	Keno Impoundment water quality/algae/nutrients	14	2	$54	$91	99	$4,601	$7,770
58	Keno Impoundment to Tributaries: Meteorology (weather stations)	14	0	$0	$0	50	$2,316	$3,911
59	Remote Sensing acquisition and analysis	No in-region spending, no regional economic effects						
60	Keno Dam fish passage	No in-region spending, no regional economic effects						
63	Klamath Basin Wildlife Refuges: O&M North and P Canals	No funding identified in C2						
64	Klamath Basin Wildlife Refuges: Walking Wetland Construction	15	0	$0	$0	40	$1,955	$3,799
65	Klamath Basin Wildlife Refuges: Big Pond Dike Construction	No funding identified in C2						
66	On Project water plan	Evaluated in Irrigated Agriculture Economics Technical Report						
67	Groundwater Technical Investigation	No in-region spending, no regional economic effects						
68	Costs Associated with Remedy for Adverse Impact	No funding identified in C2						
69	D Pumping Plant	Transfer payment, no regional economic effects						
70	Water Use Retirement Plan	Evaluated in Irrigated Agriculture Economics Technical Report						
71	Off Project Plan and Program: Use of 30K ac ft above UKL	Evaluated in Irrigated Agriculture Economics Technical Report						
72	Interim Power Sustainability	Evaluated in Irrigated Agriculture Economics Technical Report						
73	Federal Power	Transfer payment, no regional economic effects						
74	Energy Efficiency and Renewable Resources	4	0	$0	$0	54	$2,278	$6,211
75	Renewable Power Program Financial and Engineering Plan	No in-region spending, no regional economic effects						

Table P-83. KBRA Regional Economic Effects Summary (2012 dollars)

#	KBRA Action	Action span (years)	Total Effects[1] of Base Funding: Employment (Jobs)[2]	Total Effects[1] of Base Funding: Labor Income (1000$)[3]	Total Effects[1] of Base Funding: Output (1000$)[4]	Total Effects[1] of KBRA Funding (over and above Base Funding): Employment (Jobs)[2]	Total Effects[1] of KBRA Funding (over and above Base Funding): Labor Income (1000$)[3]	Total Effects[1] of KBRA Funding (over and above Base Funding): Output (1000$)[4]
76	UKL Wetlands Restoration: Agency/Barnes	5	0	$0	$0	34	$1,576	$4,108
77	UKL Wetlands Restoration: Wood River	5	0	$0	$0	34	$1,576	$4,108
78	Drought Plan Development	Action near complete						
79	Drought Plan Restoration Agreement Fund	Evaluated in Irrigated Agriculture Economics Technical Report						
80	Emergency Response Plan	No funding identified in C2						
81	Emergency Response Fund	No funding identified in C2						
82	Technical Assessment of Climate Change	No in-region spending, no regional economic effects						
83	Off-Project Reliance Program	Evaluated in Irrigated Agriculture Economics Technical Report						
84	Real Time Water Management	No funding identified in C2						
85	Real Time Water Management: Water Flow Monitoring and Gauges	15	0	$0	$0	51	$2,455	$3,892
86	Snowpack Gauges	No funding identified in C2						
87	Adaptive Management: Science and Analysis	10	0	$0	$0	17	$824	$1,307
88	Real Time Management: Calibration and improvements to KLAMSIM or other modeling and predictions	2	0	$0	$0	3	$84	$131
61	Data Analysis and evaluation for provision to TAT	9	0	$0	$0	3	$126	$197
62	Development of predictive techniques	9	0	$0	$0	7	$298	$471
89	Interim Flow and Lake Level Program	Evaluated in Irrigated Agriculture Economics Technical Report						
90	Keno Impoundment KIP Screening	4	0	$0	$0	67	$3,170	$8,270
91	Federal GCP/HCP	8	0	$0	$0	79	$3,851	$6,105
92	California Laws	No funding identified in C2, state would pay for program						
93	Oregon Laws	No funding identified in C2, state would pay for program						
94	Klamath County Study	No funding identified in C2						
95	Klamath County	$3.2 million to Klamath County, unknown how funds would be spent at this time. Effects not quantified. Expected to result in positive regional economic effects to employment, labor income and output						
96	Siskiyou County	$20 million to Siskiyou County, unknown how funds would be spent at this time. Effects not quantified. Expected to result in positive regional economic effects to employment, labor income and output						
97	Humboldt County	No funding identified in C2						

Table P-83. KBRA Regional Economic Effects Summary (2012 dollars)

#	KBRA Action	Action span (years)	Total Effects[1] of Base Funding			Total Effects[1] of KBRA Funding (over and above Base Funding)		
			Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]	Employment (Jobs)[2]	Labor Income (1000$)[3]	Output (1000$)[4]
98	Del Norte County	No funding identified in C2						
99	Fisheries Management Hoopa Valley Tribe	Upon becoming a Party to the KBRA in accordance with Section 38, the Hoopa Valley Tribe will be eligible for funding in categories and amounts for each of the other tribes in line items 99 through 110						
100	Fisheries Management Karuk	15	169	$7,505	$11,643	66	$2,891	$4,485
101	Fisheries Management Klamath	15	118	$5,935	$9,717	73	$3,630	$5,943
102	Fisheries Management Yurok	15	141	$6,792	$12,108	89	$4,252	$7,581
103	Conservation Management Hoopa Valley Tribe	0	Upon becoming a Party to the KBRA in accordance with Section 38, the Hoopa Valley Tribe will be eligible for funding in categories and amounts for each of the other tribes in line items 99 through 110					
104	Conservation Management Karuk	15	68	$3,012	$4,672	50	$2,187	$3,393
105	Conservation Management Klamath	15	56	$2,771	$4,537	41	$2,013	$3,296
106	Conservation Management Yurok	15	67	$3,188	$5,724	49	$2,315	$4,156
107	Economic Development Study Hoopa Valley Tribe	Upon becoming a Party to the KBRA in accordance with Section 38, the Hoopa Valley Tribe will be eligible for funding in categories and amounts for each of the other tribes in line items 99 through 110						
108	Economic Development Study Karuk	1	0	$0	$0	6	$197	$406
109	Economic Development Study Klamath	1	0	$0	$0	6	$197	$406
110	Economic Development Study Yurok	1	0	$0	$0	6	$197	$406
111	Klamath Tribes: Mazama Forest Project	Transfer payment to private owner for land purchase for tribe, total is $21 million. Regional effects not quantified. Tribe would benefit in future from use of forest lands.						
112	Fishing Sites	No funding identified in C2						

Source: IMPLAN presented in 2012 dollars
UKL: Upper Klamath Lake
USFS: United States Forest Service
BLM: Bureau of Land Management
[1] Total Effect = Direct + Indirect + Induced Effects
[2] Employment is measured in number of jobs (full-time, part-time, and temporary). Construction-related employment estimates include the in-field workforce plus all additional jobs generated by project construction expenditures, e.g., in retail, services, manufacturing, and other related sectors throughout the economy.
[3] Income is the dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals located within the analysis area.
[4] Output represents the dollar value of industry production.

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Table 1: Revised Appendix C-2, Cost Estimates for Federal Funding to Implement the Klamath Basin Restoration Agreement

June 20, 2011

($2007 Millions)

Program	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total
Coordination	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 0.1	$ 1.5
Fisheries																
Restoration	$ 0.9	$ 7.9	$ 10.7	$ 12.5	$ 14.5	$ 16.6	$ 21.9	$ 44.4	$ 44.0	$ 21.7	$ 15.4	$ 13.4	$ 11.5	$ 9.9	$ 8.3	$ 253.4
Reintroduction	$ 0.4	$ 1.3	$ 1.9	$ 2.4	$ 2.6	$ 4.2	$ 13.9	$ 5.3	$ 8.5	$ 4.8	$ 3.6	$ 3.6	$ 3.6	$ 3.6	$ 3.6	$ 63.4
Monitoring	$ 0.1	$ 5.9	$ 6.3	$ 5.9	$ 5.9	$ 6.2	$ 6.7	$ 7.3	$ 8.2	$ 8.3	$ 8.8	$ 8.8	$ 9.2	$ 8.9	$ 8.6	$ 104.7
Water Resources	$ 10.4	$ 30.7	$ 36.8	$ 31.7	$ 33.2	$ 29.4	$ 29.7	$ 30.5	$ 14.3	$ 3.7	$ 1.5	$ 1.5	$ 1.5	$ 1.5	$ 1.5	$ 257.8
Regulatory Assurances	$ -	$ -	$ -	$ 0.4	$ 1.0	$ 0.8	$ 1.0	$ 12.4	$ 14.3	$ 0.5	$ 0.5	$ -	$ -	$ -	$ -	$ 30.7
Counties*	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tribes	$ 12.3	$ 16.3	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 4.5	$ 87.0
TOTAL KBRA COSTS*	**$ 24.2**	**$ 62.1**	**$ 60.4**	**$ 57.4**	**$ 61.8**	**$ 61.8**	**$ 77.7**	**$ 104.4**	**$ 93.9**	**$ 43.5**	**$ 34.2**	**$ 31.9**	**$ 30.4**	**$ 28.4**	**$ 26.5**	**$ 798.5**

***This is not a Federal budget product, it was developed by the states, agency represenatives, tribes, and other non-federal parties to the KBRA.**

Table 1: Detailed Cost Estimates for the Klamath Basin Settlement Agreement

($2007 Thousands)

#	Project	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	SUM
1	Coordination and Oversight	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,500
2	Planning & Impl. -- Ph. I and Ph. II Restoration Plans	700	200	-	-	-	-	-	-	1,000	600	-	-	-	-	-	2,500
3	Williamson R. aquatic habitat restoration	-	223	336	358	459	330	402	443	390	425	419	155	155	155	23	4,272
4	Sprague R. aquatic habitat restoration	108	1,347	3,302	3,494	3,947	2,965	3,465	4,636	4,912	5,204	5,436	5,063	3,127	1,628	466	49,099
5	Wood R. Valley aquatic habitat restoration	27	182	369	433	681	936	3,021	2,112	761	1,564	1,411	431	415	314	27	12,684
6	Williamson Sprague Wood Screening Diversion (n=~100)	-	209	209	209	209	209	209	209	209	209	209	209	209	209	211	2,933
7	Williamson & Sprague USFS uplands	-	500	500	800	800	800	800	800	800	800	800	800	800	1,000	1,000	11,000
8	Upper Klamath Lake aquatic habitat restoration	-	29	48	48	298	519	1,125	4,999	4,999	625	-	-	-	-	-	12,692
9	Screening of UKL pumps (underway)	-	35	35	35	35	35	35	35	35	35	35	35	35	35	35	489
10	UKL watershed USFS uplands	-					-	220	1,000	1,000	1,000						3,220
11	UKL and Keno nutrient reduction	-	1,132	1,132	1,132	1,132	2,253	2,253	17,574	17,574	901	901	901	901	901	901	49,589
12	Keno Res. wetlands restoration	-	-	-	-	-	125	125	2,248	2,498	-	-	-	-	-	-	4,995
13	Keno to Iron Gate upland private & BLM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Keno to Iron Gate upland USFS (Goosenest)	-	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,400
15	Keno to Iron Gate mainstem restoration	-	100	100	100	100	100	150	200	200	200						1,250
16	Keno to Iron Gate tributaries - diversions & riparian	-	-	-	-	500	500	500	-	-	-						1,500
17	Shasta River aquatic habitat restoration	100	200	200	500	500	900	1,000	1,000	1,200	1,200	1,200	1,200	1,200	1,000	1,000	12,400
18	Shasta R. USFS uplands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Scott River aquatic habitat restoration	-	100	500	750	900	900	900	900	-	-	-	-	-	-	-	4,950
20	Scott R. USFS uplands	-	100	250	300	100	150	150	200	200	180	-	-	-	-	-	1,630
21	Scott R. private uplands	-	-	125	200	250	-	-	-	-	-	-	-	-	-	-	575
22	Mid-Klamath & tribs aquatic habitat restoration	-	200	200	250	350	350	400	400	400	400	400	400	400	400	400	4,950
23	Mid Klamath tribs USFS upland	-	600	600	600	600	600	600	600	700	750	750	750	750	750	750	9,400
24	Mid Klamath tribs private upland	-	600	600	600	600	600	600	600	700	700	-	-	-	-	-	5,600
25	Lower Klamath aquatic habitat restoration	-	500	500	900	1,200	1,900	2,000	2,500	2,500	3,000	-	-	-	-	-	15,000
26	Lower Klamath private/tribal uplands	-	1,000	1,000	1,000	1,000	1,500	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	32,500
27	Salmon River aquatic hab restoration	-	200	200	300	300	400	400	400	400	400	320	-	-	-	-	3,320
28	Salmon R. USFS upland	-	300	400	400	400	400	400	400	400	400	400	400	400	400	400	5,500
29	Reintroduction Plan	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,500
30	Collection Facility	-	-	-	-	-	-	-	988	4,238	500	238	238	238	238	238	6,916
31	Production Facility	-	-	-	-	-	750	4,000	285	285	285	285	285	285	285	285	7,030
32	Acclimation Facility	-	-	-	-	-	850	2,285	285	285	285	285	285	285	285	285	5,415
33	Transport	-	-	-	-	-	-	-	95	95	95	95	95	95	95	95	760
34	Monitoring and Evaluation - Oregon	190	1,000	1,500	2,000	2,200	2,200	2,200	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	30,490
35	Monitoring and Evaluation - California	95	190	190	190	190	190	190	190	190	190	190	190	190	190	190	2,755
36	New Hatchery (IGD or Fall Creek)	-	-	143	143	143	143	5,083	950	950	950	-	-	-	-	-	8,503
37	Adult Salmonids	-	607	607	607	607	607	607	607	1,607	1,685	1,685	1,685	1,685	1,685	1,685	15,963
38	Juvenile Salmonids	-	471	471	471	471	471	971	1,116	1,471	1,471	1,971	1,971	1,971	1,971	1,971	17,240
39	Genetics Otololith	-	80	80	80	80	80	100	100	100	100	100	100	100	200	200	1,500
40	Hatchery Tagging (PacifiCorp paying costs under KHSA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Disease	-	519	519	519	519	519	519	519	519	519	519	519	519	519	519	7,268
42	Green Sturgeon	-	161	161	161	161	161	161	161	161	161	161	161	161	161	161	2,256
43	Lamprey	-	153	153	153	153	153	153	153	153	153	153	153	153	153	153	2,138
44	Geomorphology	-	-	-	-	-	300	300	300	300	300	300	300	300	300	-	2,700

Table 1: Detailed Cost Estimates for the Klamath Basin Settlement Agreement

($2007 Thousands)

#	Project	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	SUM
45	Habitat Monitoring	-	193	193	193	193	193	193	193	193	193	193	193	193	193	193	2,700
46	Water Quality	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,500
47	UKL continuous water quality, hydrodynamic model	-	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,400
48	UKL nutrients/algae/zooplankton	-	405	405	405	405	405	405	405	405	405	405	405	405	405	405	5,670
49	UKL internal load/bloom dynamics	-	200	200	200	200	200	200	200	200	200	200	200	200	200	200	2,800
50	UKL external nutrient loading	-	259	259	259	259	259	259	259	259	259	259	259	259	259	259	3,626
51	UKL analysis of long-term data sets	-	-	200	-	-	-	-	200	-	-	-	-	200	-	-	600
52	UKL listed suckers	-	875	875	875	875	875	875	875	875	875	875	875	875	875	875	12,250
53	Tributaries water quality/nutrients/temperature	-	310	310	310	310	310	310	310	310	310	310	310	310	310	310	4,340
54	Tributaries geomorphology/riparian vegetation	-	239	239	239	239	239	239	239	239	239	239	239	239	239	239	3,346
55	Tributaries physical habitat	-	213	213	213	213	213	213	213	213	213	213	213	213	213	213	2,982
56	Tributaries listed suckers	-	375	375	375	375	375	375	375	375	375	375	375	375	375	375	5,250
57	Keno Reservoir water quality/algae/nutrients	-	402	402	402	402	402	402	402	402	402	402	402	402	402	402	5,628
58	Keno Reservoir to Tributaries: (weather stations)	-	200	200	200	200	200	200	200	200	200	200	200	200	200	200	2,800
59	Remote Sensing acquisition and analysis	-	-	250	-	-	-	-	250	-	-	-	-	250	-	-	750
60	Keno Dam fish passage	-	-	-	-	-	-	-	-	1,500	2,000	-	-	-	-	-	3,500
61	Data Analysis and evaluation for provision to TAT	-	100	8	8	8	8	8	5	5	5	-	-	-	-	-	155
62	Development of predictive techniques	-	200	20	20	20	20	20	20	20	20	-	-	-	-	-	360
63	Klamath Basin Wildlife Refuges: North and P Canals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	Klamath Basin Wildlife Refuges: Walking Wetland Construction	210	215	215	215	215	215	215	100	100	100	100	100	100	100	100	2,300
65	Klamath Basin Wildlife Refuges: Big Pond Dike	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	On Project water plan	1,200	4,300	8,000	9,000	15,000	15,000	15,000	15,000	10,000	-	-	-	-	-	-	92,500
67	Groundwater Technical Investigation	111	285	245	-	-	-	-	-	-	-	-	-	-	-	-	641
68	Costs Associated with Remedy for Adverse Impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	D Pumping Plant	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	2,550
70	Water Use Retirement Plan	200	400	200	100	100	-	-	-	-	-	-	-	-	-	-	1,000
71	Off Project Plan and Program: Use of 30K ac ft above UKL	-	2,000	6,000	7,000	7,000	8,000	8,000	7,000	-	-	-	-	-	-	-	45,000
72	Interim Power Sustainability	1,730	2,241	3,719	-	-	-	-	-	-	-	-	-	-	-	-	7,690
73	Federal Power	500	500	-	-	-	-	-	-	-	-	-	-	-	-	-	1,000
74	Energy Efficiency and Renewable Resources	-	13,886	12,378	9,368	4,866	-	-	-	-	-	-	-	-	-	-	40,498
75	Renewable Power Program Financial and Engineering Plan	500	500	-	-	-	-	-	-	-	-	-	-	-	-	-	1,000
76	UKL Weltands Restoration: Agency/Barnes	-	-	-	-	56	167	333	2,083	139	-	-	-	-	-	-	2,777
77	UKL Wetlands Restoration: Wood River	-	-	-	-	-	56	167	333	2,083	139	-	-	-	-	-	2,777
78	Drought Plan Development	-	-	-	-	-	-	-	-	-	-	-					-
79	Drought Plan Restoration Agreement Fund	-	-	-	-	-	-	-	-	-	1,000	1,000	1,000	1,000	1,000	1,000	6,000
80	Emergency Response Plan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	Emergency Response Fund	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Technical Assessment of Climate Change	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	Off-Project Reliance Program	-	-	-	-	-	-	-	12000*	-	-	-	-	-	-	-	12000*
84	Real Time Water Management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85	Real Time Water Management: Water Flow Monitoring and Gauges	200	250	250	200	200	200	200	185	185	185	185	185	185	185	185	2,980
86	Added Snowpack Gauges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87	Adaptive Management: Science and Analysis	100	100	100	100	100	100	100	100	100	100	-	-	-	-	-	1,000
88	Real Time Management: Calibration and improvements to KLAMSIM or other modeling and predictions	-	50	-	-	-	-	-	50	-	-	-	-	-	-	-	100

Table 1: Detailed Cost Estimates for the Klamath Basin Settlement Agreement

($2007 Thousands)

#	Project	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	SUM
89	Interim Flow and Lake Level Program	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	-	-	-					44,000
90	Keno Reservoir KIP Screening	-	-	-	-	-	151	151	11,021	13,839	-	-	-	-	-	-	25,162
91	Federal GCP/HCP	-	-	-	350	1,000	650	800	1,350	450	450	450	-	-	-	-	5,500
92	California Laws	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93	Oregon Laws	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94	Klamath County Study	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95	Klamath County (Oregon funding)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
96	Siskiyou County	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
97	Humboldt County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98	Del Norte County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
99	Fisheries Management HVT**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100	Fisheries Management Karuk	500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	14,500
101	Fisheries Management Klamath	500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	14,500
102	Fisheries Management Yurok	500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	14,500
103	Conservation Management HVT**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
104	Conservation Management Karuk	250	500	500	500	500	500	500	500	500	500	500	500	500	500	500	7,250
105	Conservation Management Klamath	250	500	500	500	500	500	500	500	500	500	500	500	500	500	500	7,250
106	Conservation Management Yurok	250	500	500	500	500	500	500	500	500	500	500	500	500	500	500	7,250
107	Economic Development Study HVT**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
108	Economic Development Study Karuk	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	250
109	Economic Development Study Klamath	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	250
110	Economic Development Study Yurok	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	250
111	Klamath Tribes: Mazama Forest Project	10,000	11,000	-	-	-	-	-	-	-	-	-	-	-	-	-	21,000
112	Fishing Sites	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Recognizes there is further discussion of additional funding potentially available, including reallocated funds and provisions of KBRA Section 19.5.2.

** Upon becoming a Party to the KBRA in accordance with Section 38, the Hoopa Valley Tribe will be eligible for funding in categories and amounts for each of the other tribes in line items 99 through 110.

Appendix Q
Aesthetics/Visual Resources Technical Report

Q.1 Comparison of 2010 to 2002/2003 Conditions

The Lead Agencies used the results of the *Land Use, Visual, and Aesthetic Resources Final Technical Report* (PacifiCorp 2004) in the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) to establish the existing environmental setting of the area of analysis. To verify that conditions are similar to those of 2003 and that the conclusions made using these 2002/2003 photographs are still applicable, photographs taken from selected locations in October 2010, referenced as CDM 2010, were compared to the 2003 photographs.

Q.1.1 J.C. Boyle Dam and Facilities

J.C. Boyle Dam 5 (CDM 2010)

BB1: J.C. Boyle Dam (FERC 2004)

BB3: Outflow From J.C. Boyle Dam—View From Access Road (FERC 2004)

Q.1.2 J.C. Boyle Dam Looking Downstream

J.C. Boyle Dam looking Downstream (CDM 2010)

BB2: Klamath River From Bridge Below J. C. Boyle Dam Downstream (FERC 2004)

Q.1.3 J.C. Boyle Dam_Topsy Recreational Center Site

J.C. Boyle Dam_Topsy Recreational Center Site (CDM 2010)

Topsy Recreational Center (FERC 2004)

Q.1.4 Copco Cove Rec Area 2


Copco Cove Rec Area 2 (CDM 2010)


Copco Cove (FERC 2004)

Q.1.5 Long Gulch


Long Gulch (CDM 2010)


Long Gulch (FERC 2004)

Q.1.6 Iron Gate Boat Launch


Iron Gate Boat Launch (CDM 2010)


Iron Gate Access Boat Launch (FERC 2004)


Iron Gate Access (FERC 2004)

Q.1.7 Klamath River From Fishing Access #5


Ager-Beswick Fishing Access point_South of Klamath River (CDM 2010)


HC8: Klamath River From Fishing Access #5 (Topsy Grade Road) Downstream (FERC 2004)

Q.2 Typical Scenic/Landscape Character along the Klamath River

The following photographs from the *Land Use, Visual, and Aesthetic Resources Final Technical Report* (PacifiCorp, 2004) identify typical scenic/landscape character along the Klamath River, including its elements of canyon-walled enframement, channel configuration, water clarity, bank and riparian appearance.

Q2.1 BB2: Klamath River from Bridge Below J. C. Boyle Dam


Upstream (low flow= 100 cfs)


Downstream (low flow = 100 cfs))

Q2.2 BB4: J.C. Boyle Bypass Reach View #1 from Access Road

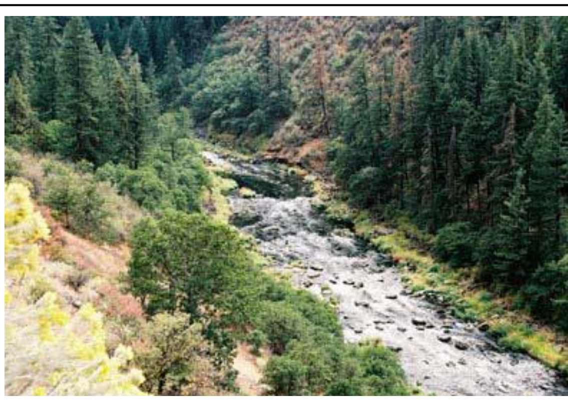
Upstream (low flow= 325 cfs)

Downstream (low flow = 325 cfs))

Q2.3 BB5: J.C. Boyle Bypass Reach View #2 from Access Road

Upstream (low flow= 325 cfs)

Q2.4 BB6: J. C. Boyle Bypass Reach View #3 from Access Road



Upstream (low flow= 325 cfs)

Downstream (low flow = 325 cfs))

Q2.5 BB7: J. C. Boyle Bypass Reach View #4 from Access Road


Upstream (low flow= 325 cfs)


Downstream (low flow = 325 cfs))

Q2.6 HC5: Klamath River from Frain Ranch Boater Access


Upstream (low flow= 350 cfs)


Downstream (low flow = 350 cfs))

Q2.7 HC6: Klamath River (Caldera Rapids) from Frain Ranch


Upstream (low flow= 350 cfs)


Downstream (low flow = 350 cfs))

Q2.8 HC7: Klamath River from Stateline Takeout


Looking Upstream (low flow= 350 cfs)

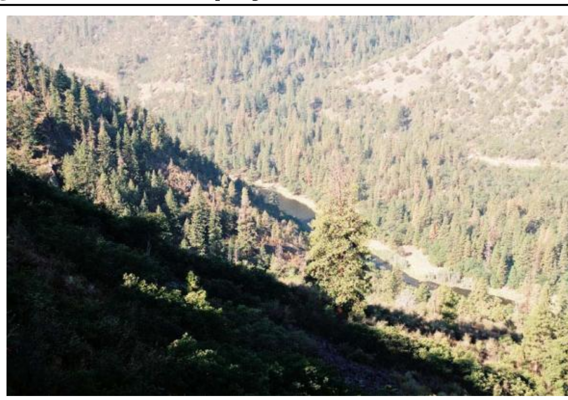

Looking Downstream (low flow= 350 cfs)

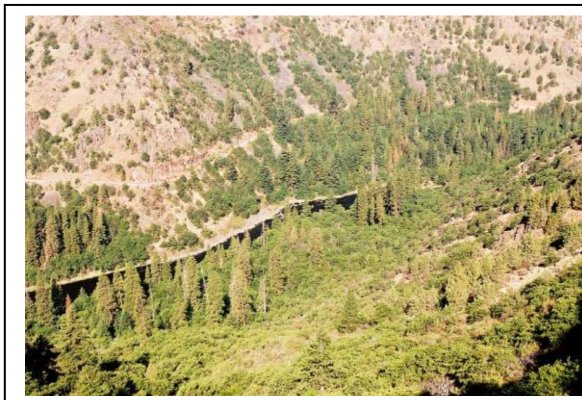
Q2.9 HC8: Klamath River from Fishing Access #5 (Topsy Grade Road)


Upstream (low flow= 350 cfs)


Downstream (low flow = 350 cfs))

Q2.10 HC3: Topsy Grade Road Potential Overlook #2


Looking Upstream


Looking Downstream

Q2.11 HC4: Topsy Grade Road Potential Overlook #3

Looking Upstream

Looking Downstream

Q2.12 IG12: Klamath River from Iron Gate Hatchery River Access

Upstream (medium flow= 1350 cfs)

Downstream (medium flow = 1350 cfs)

Q.3 References

PacifiCorp. 2004. Land Use, Visual, and Aesthetic Resources Final Technical Report. Klamath Hydroelectric Project, No. 2082.

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Appendix R
Recreation Data Input

The following table summarizes flows acceptable for fishing and whitewater boating opportunities in the various reaches of the Klamath River. The table also includes the number of days per month with acceptable flows for each activity under the No Action/ No Project Alternative ("dams in" in the table below) and the Proposed Action "dams out" in the table below). This data is presented graphically in Section 3.20, Recreation.

Table R-1. Summary of Acceptable Flow Data for Whitewater Boating and Fishing

		Acceptable Flows		Total Avg. Annual No Days with Acceptable Flows		
River Reach	Activity	Low Value (cfs)	High Value (cfs)	Dams In	Dams Out	Percent Difference
Keno Reach	Whitewater Boating	1000	4000	151.29	139.30	-7.93%
	Fishing	200	1500	246.10	237.53	-3.48%
J.C. Boyle Bypass Reach	Whitewater Boating	1300	1800	4.63	41.35	793.56%
	Fishing	200	1000	106.96	141.86	32.63%
Hells Corner Reach	Whitewater Boating/Rafting	1300	3500	277.98	119.33	-57.07%
	Fishing	200	1500	234.37	228.07	-2.69%
Copco 2 Bypass Reach	Whitewater Boating	600	1500	10.22	223.09	2083.83%
	Fishing	50	600	13.75	2.84	-79.36%
Iron Gate to Scott River	Whitewater Boating/Fishing	800	4000	278.04	280.86	1.01%
Scott River to Salmon River	Boating	800	7000	242.96	246.26	1.36%
	Fishing	800	4000	174.92	182.23	4.18%
Salmon River to Trinity River	Whitewater Boating/Fishing	800	10000	207.00	210.67	1.78%
Trinity River to Ocean	Whitewater Boating/Fishing	1800	18000	238.86	238.33	-0.22%

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Appendix S
Transportation and Circulation Analysis Data

This appendix presents a detailed analysis of the hauling and worker trips for each alternative. Hauling trips include trips to a local recycling facility in Weed, California, as well as truck trips for additional deconstructed materials to disposal sites outside of the project boundaries.

Table S-1. Alternative 2 Hauling and Worker Trips

		Alternative 2 - Full Removal								
		J.C. Boyle		Copco 1		Copco 2		Iron Gate		
Roads	Baseline (projected) AADT	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Total AADT
Interstate 5 (California) (1)	18,350			56	10	64	34	80	10	18,604
Interstate 5 (Oregon)	15,100	12								15,112
OR66	490	72	20							582
US97	9,300	60	20							9,380
Copco Rd (2)	250			56	10	64	34	80	10	504
Topsy Grade Rd (2)	200		20							220
Unpaved Access Roads (2)	30		420		100		200		1700	2,450

(1) Uses peak month AADT to determine 2020 baseline

(2) Estimated Average Daily Traffic is based on field observations

Table S-2. Alternative 3 Hauling and Worker Trips

Roads	Baseline (projected) AADT	Alternative 3 - Partial Removal								
		J.C. Boyle		Copco 1		Copco 2		Iron Gate		
		Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Total AADT
Interstate 5 (California) (1)	18,350			56	10	60	34	80	10	18,600
Interstate 5 (Oregon)	15,100	11								15,111
OR66	490	64	20							574
US97	9,300	53	20							9,373
Copco Rd (2)	250			56	10	60	34	80	10	500
Topsy Grade Rd (2)	200		20							220
Unpaved Access Roads (2)	30		420		100		200		1700	2,450

(1)Uses peak month AADT to determine 2020 baseline

(2)Estimated Average Daily Traffic is based on field observations

Table S-3. Alternative 4 Hauling and Worker Trips

Roads	Baseline (projected) AADT	Alternative 4 - Fish Passage Four Dams (2)								
		J.C. Boyle		Copco 1		Copco 2		Iron Gate		
		Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Total AADT
Interstate 5 (California) (1)	18,350			40		24		40		18,454
Interstate 5 (Oregon)	15,100	4								15,104
OR66	490	24								514
US97	9,300	20								9,320
Copco Rd (2)	250			40		24		40		354
Topsy Grade Rd (2)	200									200
Unpaved Access Roads (2)	30		18		18		18		18	102

(1)Uses peak month AADT to determine 2020 baseline

(2)Estimated Average Daily Traffic is based on field observations

Table S-4 Alternative 5 Hauling and Worker Trips

		Alternative 5 - Remove 2 Dams FP 2 Dams (2)								
		J.C. Boyle		Copco 1		Copco 2		Iron Gate		
Roads	Baseline (projected) AADT	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Workers (daily trips)	Hauling (daily trips)	Total AADT
Interstate 5 (California) (1)	18,350			56	10	24		80	10	18,530
Interstate 5 (Oregon)	15,100	4								15,104
OR66	490	24								514
US97	9,300	20								9,320
Copco Rd (2)	250			56	10	24		80	10	430
Topsy Grade Rd (2)	200									200
Unpaved Access Roads (2)	30		18		100		18		1700	1,866

(1)Uses peak month AADT to determine 2020 baseline

(2)Estimated Average Daily Traffic is based on field observations

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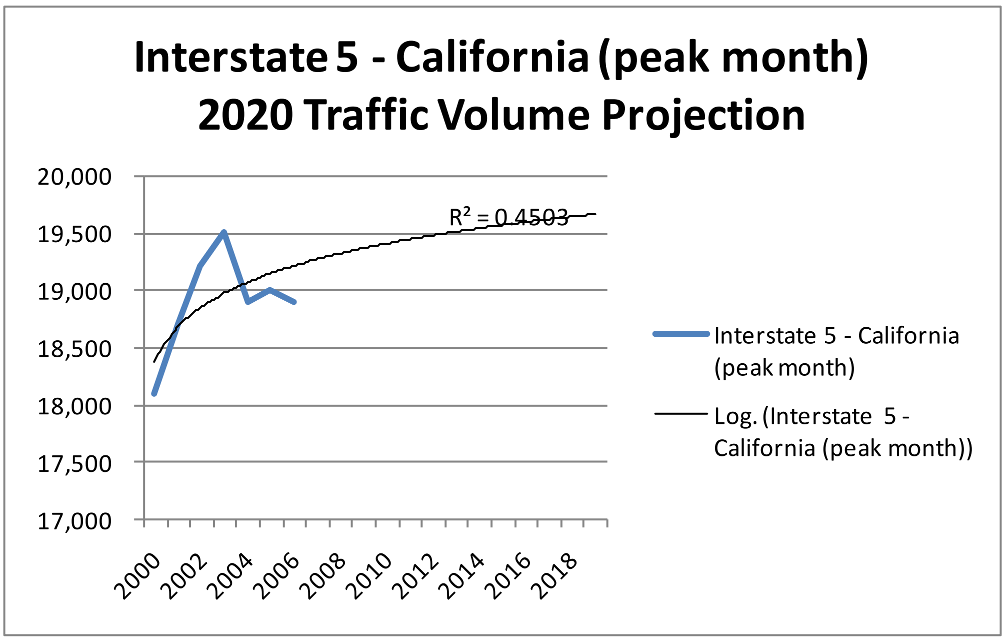
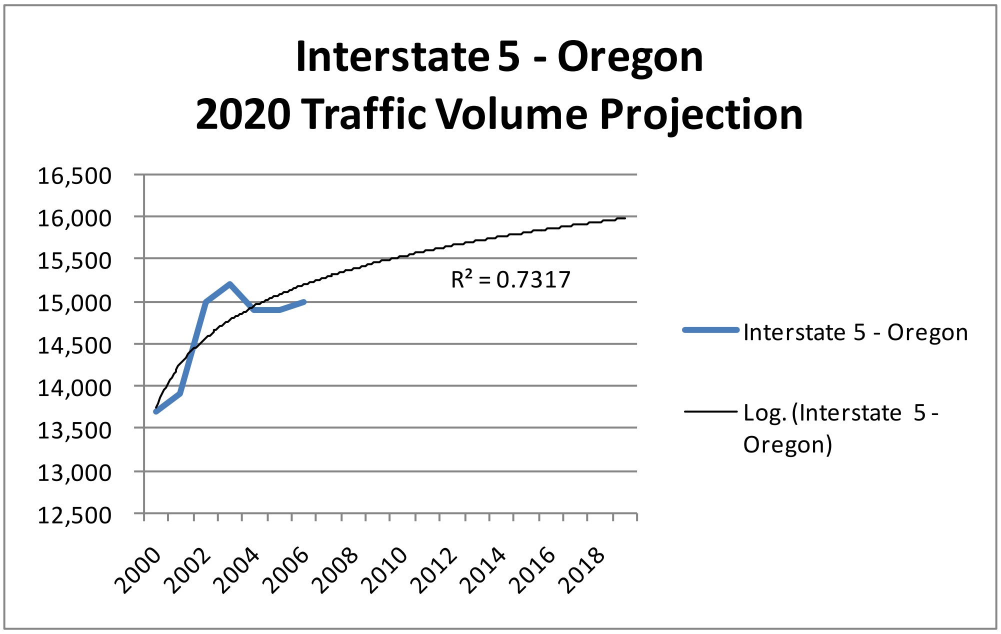
Appendix T
2020 Traffic Volume Projections

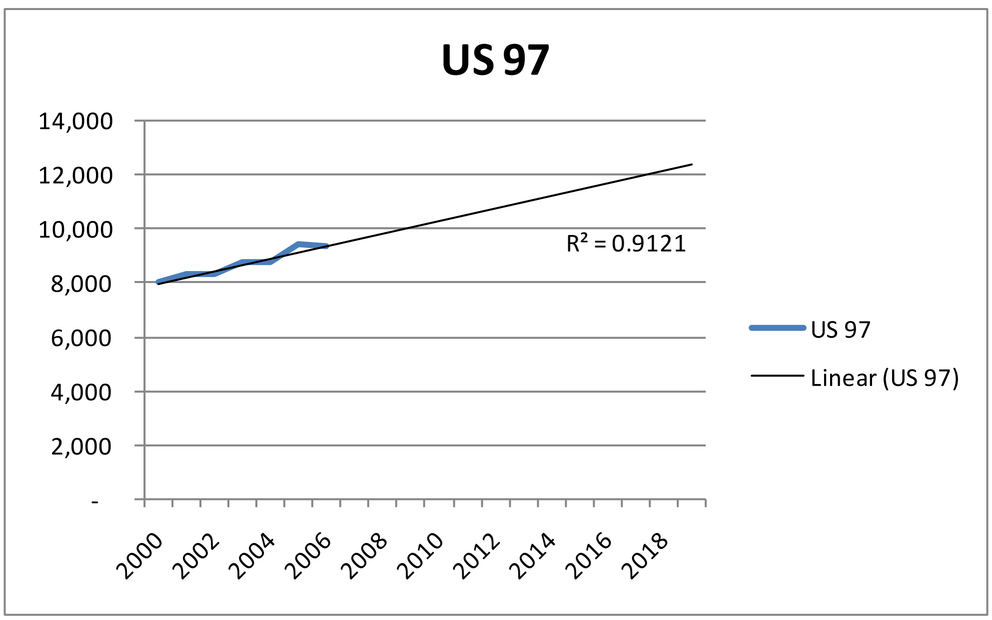
The Lead Agencies considered two components of traffic growth in evaluating future year conditions. First, the team determined an annual background growth rate based on historical data from 2000 through 2009. The Lead Agencies used that data to create a trend line and project a baseline traffic volume to 2020. This appendix includes the graphs showing these projections.



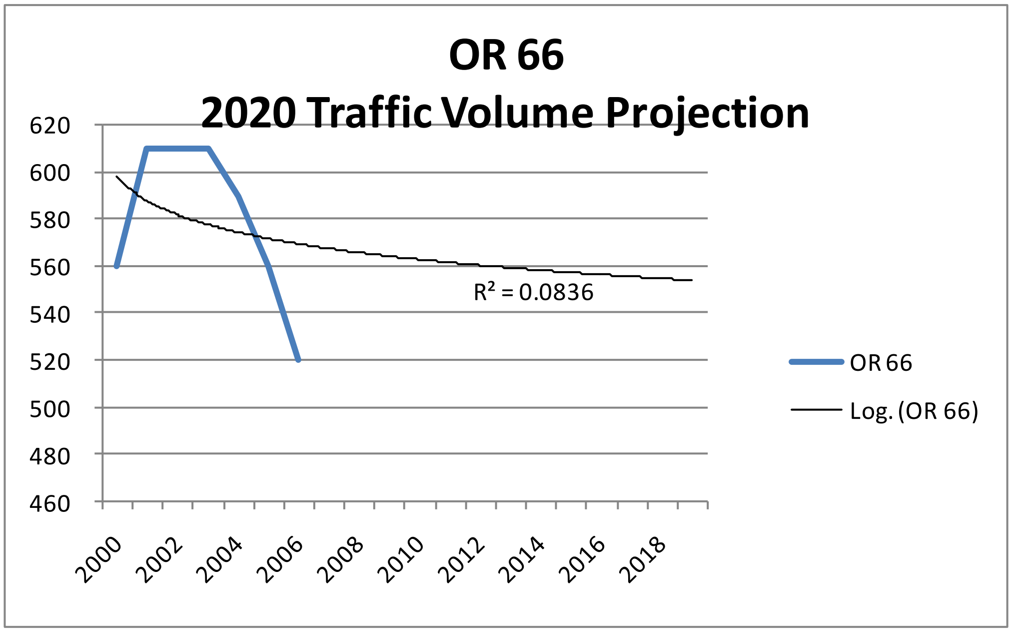
Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM



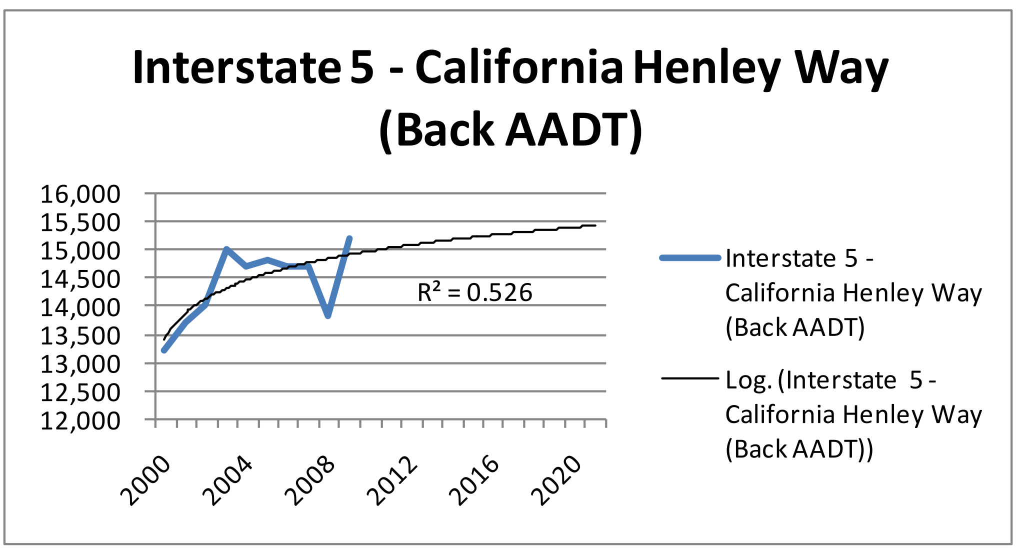
Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM



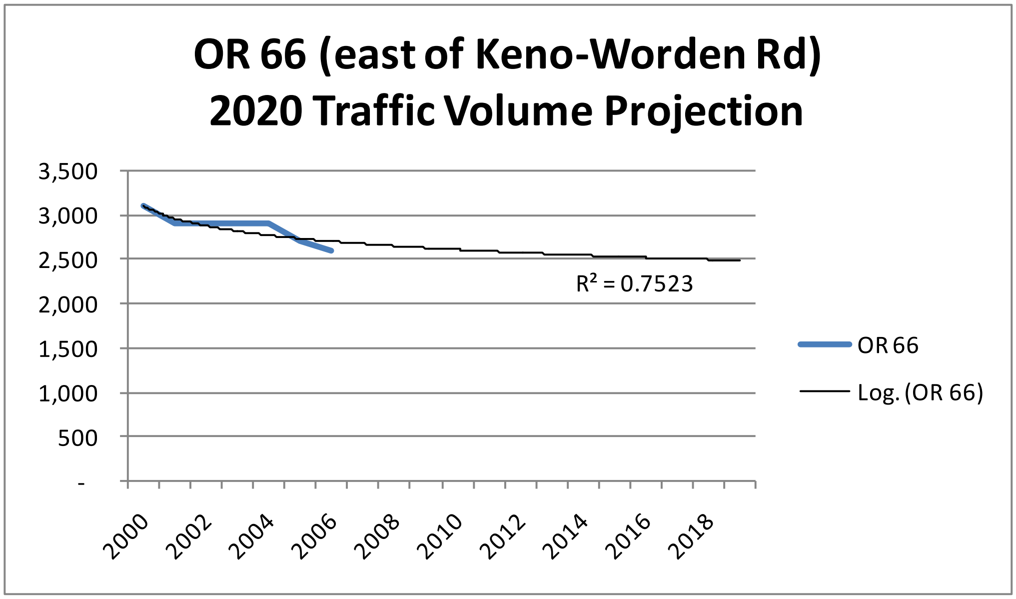
Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM



Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM



Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM
AADT is Annual Average Daily Traffic.



Source: Caltrans Traffic Data Branch and ODOT Traffic Counting Program, projections by CDM

T.1 References

Caltrans Traffic Data Branch. 2010. Accessed November 2010 at http://traffic-counts.dot.ca.gov/index.htm

Oregon Department of Transportation. 2010. Traffic Counting Program. Accessed November 2010 at http://www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml

Appendix U
Noise and Vibration Impact Analysis

This appendix describes basic noise and vibration concepts and the methods used to assess the potential construction and vehicle noise impacts. Attachment 1 presents the results of the construction noise impact analysis. Attachment 2 includes the vibration impact analysis. Traffic noise modeling inputs and outputs are presented in Attachment 3.

U.1 Noise Concepts

Sound is mechanical energy characterized by the rate of oscillation of sound waves (frequency), the speed of propagation, and the pressure level (amplitude). The human ear perceives sound as pressure on the ear. The sound pressure level is the logarithmic ratio of that perceived pressure to a reference pressure, and is expressed in decibels (dB). Approximately zero dB corresponds to the threshold of human hearing.

Environmental sounds are measured with the A-weighted scale of a sound level meter. The A scale simulates the frequency response of the human ear by giving more weight to the middle frequency sounds and less to the low and high frequency sounds. A-weighted sound levels are designated as dBA. Figure U-1 shows the sound levels (dBA) of and human response to common indoor and outdoor noise sources.

Because sounds in the environment usually vary with time, they cannot simply be described with a single number. The equivalent noise level (L_{eq}) is the constant sound level that, in a given period, has the same sound energy level as the actual time-varying sound pressure level. L_{eq} allows noise from various sources to be combined into a measure of cumulative noise exposure. It is commonly used by regulatory agencies to evaluate noise impacts.

In addition to evaluating noise impacts based on compliance with noise standards, project noise impacts can also be assessed by annoyance criteria, or the incremental increase in the existing noise level. The impact of increasing or decreasing noise levels is presented in Table U-1. For example, it shows that a change of 3 dBA is barely perceptible and that a 10 dBA increase or decrease would be perceived by someone to be a doubling or halving of the loudness.

Sound Source	Noise Level	Response	Hearing Effects	Conversational Relationships
	150		Contribution to Hearing Impairment Begins	
Carrier Deck				
Jet Operation	140	Painfully Loud		
	130			
		Limit Amplified Speech		
Jet Takeoff (200 ft)	120			
Auto Horn		Maximum Vocal Effort		
Riveting Machine	110			
Jet Takeoff (2000 ft)				
Garbage Truck				Shouting in Ear
	100			
NY Subway Station		Very Annoying		Shouting (2 ft)
Heavy Truck (50 ft)		Hearing Damage (8 hours)		
	90			
Pneumatic Drill (50 ft)		Annoying		Very Loud Conversation (4 ft)
Alarm Clock				
	80			
Freight Train (50 ft)				Loud Conversation (2 ft)
Freeway Traffic (50 ft)	70	Telephone Use Difficult		
Air Conditioning Unit (20 ft)	60	Intrusive		Loud Conversation (4 ft)
Light Auto Traffic (100 ft)	50	Quiet		Normal Conversation (12 ft)
Living Room				
Bedroom	40			
Library				
Soft Whisper (15 ft)	30	Very Quiet		
Broadcasting Studio	20			
		Just Audible		
	10			
	0	Threshold of Hearing		

Source: Siskiyou County, 1978.

Figure U-1. Sound Levels and Human Response

Table U-1. Decibel Changes, Loudness, and Energy Loss

Sound Level Change (dBA)	Relative Loudness	Acoustical Energy Loss (%)
0	Reference	0
-3	Barely Perceptible Change	50
-5	Readily Perceptible Change	67
-10	Half as Loud	90
-20	1/4 as Loud	99
-30	1/8 as Loud	99.9

Source: FHWA, 2011

The following general guideline was used to assess daily onsite construction noise impacts, as compared to existing ambient levels:

- A less than 3 dBA increase in sound level is considered no impact;
- A 3 to 5 dBA increase in sound level is considered a slight impact;
- A 6 to 10 dBA increase in sound level is considered a moderate impact; and
- A greater than 10 dBA increase in sound level is considered a severe impact.

This analysis assumed that an increase greater than 10 dBA would be significant and would require evaluating construction noise mitigation measures.

U.2 Vibration Concepts

Vibration is caused by oscillatory waves that propagate through the ground. Ground-borne vibration can cause building floors to shake, windows to rattle, hanging pictures to fall off walls, and in some cases damage buildings.

Like noise, vibration from a single source may consist of a range of frequencies. The magnitude of vibration is commonly expressed as the peak particle velocity (PPV) in the unit of inches per second (in/sec). The PPV is the maximum velocity experienced by any point in a structure during a vibration event and indicates the magnitude of energy transmitted through vibration. PPV is an indicator often used in determining potential damage to buildings from vibration associated with blasting and other construction activities.

Table U-2 summarizes the levels of vibration from construction equipment and the typical effects on people and buildings based on a review of published vibration levels and effects (Caltrans 2004). Although blasting is considered a transient source, human response may vary widely depending on the event duration, frequency of occurrence, startle factor, level of personal activity at the time of the event, health of the individual, time of day, orientation of the individual (standing up or lying down), and political and economic perception of the blasting operation. Ground vibration as low as 0.1 in/sec due to a blasting operation may be considered distinctly to strongly perceptible by a person.

Table U-2. Summary of Construction Equipment Vibration Levels and Effects on Humans and Buildings

Effects	Peak Particle Velocity (in/sec)	
	Transient Sources [1]	Continuous/Frequent Intermittent Sources [2]
Potentially Damaged Structure Type		
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5
Human Response		
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Source: Caltrans, 2004.

Notes:

[1] Transient sources create a single isolated vibration event, such as blasting and drop balls.

[2] Continuous/frequent intermittent sources include impact pile drivers, vibratory pile drivers, and vibratory compaction equipment.

Vibration from construction and traffic typically does not contribute to building damage, with the occasional exception of blasting and pile-driving during construction. U.S. Bureau of Mines (USBM) and Office of Surface Mining Reclamation and Enforcement (OSM) have developed a blast vibration limit ranging from 0.5 to 2.0 in/sec depending on vibration frequency and distances to protect buildings with various structure type and condition. Studies have shown that blast vibration typically does not damage residential structures even at levels exceeding USBM and OSM blast vibration limits (Caltrans 2004).

Average vibration amplitude is a more appropriate measure for human response as it takes time for the human body to respond. Average particle velocity over time is zero so the root-mean-square amplitude called the vibration velocity level (L_v) in VdB is used to quantify annoyance. For a person in their residence, the lower threshold for annoyance is 72 VdB. The L_v equivalent of the 0.12 in/sec damage criteria for fragile historic buildings is 90 VdB, a much higher value than what a person may perceive as “annoying.” (FTA 2006)

Vibration impacts from the project were considered significant if the peak particle velocity exceeded 0.3 in/sec based on the damage level for older residential structures. Vibration velocity level was considered significant if it exceeded the 72 VdB annoyance level.

U.3 Construction Noise Impact Assessment Method

Methods described in Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) User's Guide (2006) were used to estimate noise impacts associated with construction equipment and onsite waste hauling that are expected to be used in the action alternatives. Table U-3 presents noise levels of common construction equipment operating at full power (L_{max}) measured 50 feet from the source, the percent of time the equipment would be operated at full power (usage factor), and the equivalent noise level over a construction shift (FHWA 2006). To comply with the Siskiyou County regulation, the maximum allowable noise level in the Siskiyou County General Plan (1978) was used for equipment whose L_{max} in the Roadway Construction Noise Model exceeds the Siskiyou County regulation. The L_{eq} noise levels were calculated for each construction equipment using Equation 1.

Equation 1:

$$L_{eq\_equipment} = 10 \log_{10} [10^{(Lmax\_equipment/10)} \text{ x } UF_{equipment}]$$

Where:

- L_{max} is the maximum sound level for each type of equipment (dBA); and
- UF is the daily usage fraction of time that equipment is used at full power (%).

Table U-3. Construction Operations, Equipment Types, and Their Noise Levels

Equipment Types	Usage Factor	L_{max} at 50 feet (dBA)	L_{eq} at 50 feet (dBA)
Air Compressor	40%	78	74
Backhoe	40%	78	74
Blasting	1%	94	74
Compactor	20%	83	76
Concrete Mixer Truck	40%	79	75
Concrete Pump Truck[1]	20%	81	74
Crane	16%	81	73
Dozers[1]	40%	81	77
Dump Truck	40%	77	73
Excavator	40%	81	77
Front End Loader	40%	80	76
Generator	50%	81	78
Generator (< 25 kVA)	50%	73	70
Grader	40%	85	81
Jackhammer[1]	20%	81	74
Mounted Impact Hammer (hoe ram)	20%	90	83
Pickup Truck	40%	75	71
Pumps	50%	77	74
Scraper	40%	84	80
Tractor[1]	40%	81	77

Source: FHWA, 2006. Siskiyou County, 1978.

Notes:

[1] Maximum allowable noise levels from construction equipment at 100 ft from Siskiyou County's General Plan converted to noise levels at 50 ft.

Noise levels were calculated for all equipment expected to be used during peak deconstruction or construction day at each dam. Detailed equipment usage for non-peak days was not available at the time of the analysis. The individual L_{eq} of each piece of equipment was combined to obtain the total L_{eq} noise level at each construction site using Equation 2.

Equation 2:

$$L_{eq\_total\ source} = 10 \log_{10} [\Sigma\ 10^{(Leq\_equipment/10)}]$$

Natural noise attenuation from distance between the construction sites and receptors, atmospheric absorption, and terrain were subtracted from the total L_{eq} of all equipment. The equivalent L_{eq} noise levels at each noise-sensitive receptor were calculated using the following equation:

Equation 3:

$$L_{eq\_receptor} = L_{eq\_total\ source} - A_{div} - A_{ground} - A_{air} - IL_{barrier}$$

Where:

- $L_{eq\_total\ source}$ is the estimated total L_{eq} noise level at 50 feet (dBA) calculated using Equation 2;
- A_{div} is the geometrical divergence, or the distance attenuation (dBA) calculated using Equation 4;
- A_{ground} is the attenuation caused by interference between direct and ground-reflected sound (dBA) calculated using Equation 5;
- A_{air} is the attenuation due to atmospheric absorption (dBA); and
- $IL_{barrier}$ is the attenuation due to barrier, including natural terrain, (dBA) calculated with Equations 5 through 7.

Equation 4:

$$A_{div} = 20 \log_{10} (d/50)$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

This formula results in a 6-dBA loss for each doubling of distance due to spherical divergence. The distances were measured from the construction site to the closest noise-sensitive receptor.

Ground attenuation is dependent on the ground surface characteristics, distance, and source and receptor heights. Constants in Equation 5 are based on a typical construction equipment noise frequency of 500 hertz and noise source and receptor heights (h_s and h_r) of approximately five feet. The first term is the ground attenuation in the source zone, which extends from the source to $30h_s$ toward the receptor. The second term is the ground attenuation in the receptor zone, which extends from the receptor to $30h_r$ toward the source. The third term is the ground attenuation in the zone between the source and receptor zones. The ground factor (G) for each zone is zero if the ground surface consists of asphalt or concrete pavement, water, or any hard ground with low porosity. The ground factor for soft ground, or porous ground that is covered by vegetation or loose materials such as snow and pine needles, is zero. For zones with a mixture of soft and hard ground surface areas, the ground factor is the fraction of the ground that is soft.

Equation 5:

$$A_{ground} = (6.5G_s – 1.5) + (6.5G_r – 1.5) – 3\{1-[30(h_s + h_r)/d]\}(1-G_m)$$

Where:

- G_s is the ground factor for the source zone (source to $30h_s$ toward the receptor);
- G_r is the ground factor for the receptor zone (receptor to $30h_r$ toward the source);
- h_s is the source height (ft);
- h_r is the receptor height (ft);
- d is the distance between the source and the receptor; and
- G_m is the ground factor for the middle zone (between source and receptor zones).

Terrain attenuation was calculated using the Equations 6 through 8. A_{ground} in Equation 8 cancels out the term in Equation 3.

Equations 6 through 8:

$$N = (2 / \lambda)(d_1 + d_2 – d)$$

$$K = \exp\{-0.0005 \sqrt{[(d_1 d_2 d) / (N\lambda)]}\}$$

$$IL_{barrier} = 10 \log_{10}(3 + 10NK) – A_{ground}$$

Where:

- λ is the wavelength of the sound wave (ft);
- d_1 is the distance between the top of the hill and the noise source (ft);
- d_2 is the distance between the top of the hill and the noise receptor (ft);
- d is the distance between the source and the receptor (ft);
- N is called the Fresnel number;
- K is the atmospheric correction factor for d > 100 m; and
- A_{ground} is the ground attenuation, which eliminates the A_{ground} term in Equation 3.

Attenuation associated with atmospheric absorption is dependent on temperature, relative humidity, and frequency of the sound waves. It should be noted that as humidity decreases, the atmospheric attenuation increases because dry air is a poor conductor of sound compared to humid air. Based on an average air temperature of 50^oF and 50 percent humidity sound attenuates at 1.9 dB per kilometer (0.0006 dB per ft) at 500 Hz (Harris 1998).

The construction noise level calculated with the above equations must be added to the existing noise levels at the receptor to determine the noise level at the receptor resulting from construction activities. The basic concept of Equation 2 was used to add construction noise impact to existing noise levels at the receptor, as shown in Equation 8. Average daytime L_{eq} and nighttime L_{eq} noise levels for rural residential areas found in the *U.S. EPA Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* (1974) were used to estimate ambient noise levels at selected receptor locations. These levels are 40 dBA during the day (7 am to 10 pm) and 30 dBA at night (10 pm to 7am). Nighttime existing level is used at Iron Gate Dam and Copco 1 Dam receptors, where there is possible impact from nighttime construction activities.

Equation 8:

$$L_{eq\_receptor} = 10 \log_{10} [10^{(Leq\_total\ equipment/10)} + 10^{(Leq\_existing/10)}]$$

Where:

- $L_{eq\_total\ equipment}$ is the equivalent total L_{eq} noise level at the receptor due to construction activities after distance, terrain, and atmospheric attenuation are taken (dBA); and
- $L_{eq\_existing}$ is 40 dBA for daytime noise analysis and 30 dBA for nighttime noise analysis (dBA).

The existing L_{eq} was subtracted from the resulting total L_{eq} at the receptor to calculate the increase in noise levels due to construction activity. This impact was compared against the criteria of 10 dBA to determine significance.

Attachment 1 presents the results of the construction noise impact analysis.

U.4 Construction Vibration Impact Assessment Method

Vibration from construction projects is caused by general equipment operations, and is usually highest during pile driving, soil compacting, jack hammering, demolition, and blasting activities. Although it is conceivable for ground-borne vibration from construction projects to cause building damage, the vibration from construction activities is almost never of sufficient amplitude to cause even minor cosmetic damage to buildings. The primary concern is that the vibration can be intrusive and annoying to people inside buildings. Table U-4 presents the vibration levels for typical construction equipment published in Federal Transit Administration's (FTA) Transit Noise and Vibration Impact Assessment (2006).

Table U-4. Vibration Levels for Construction Equipment

Equipment Types	PPV at 25 feet (in/sec)	L_v at 25 feet (VdB)
Clam Shovel Drop	0.202	94
Vibratory Roller	0.210	94
Large Bulldozer / Hoe Ram	0.089	87
Caisson Drilling	0.089	87
Loaded Trucks	0.076	86
Jackhammer	0.035	79

Source: FTA, 2006.

Total PPV at each construction site is the sum of PPV for all equipment at the construction site. Equation 9 was used to calculate the construction equipment vibration levels at the receiver, based on a reference vibration at a distance of 25 feet.

Equation 9:

$$PPV_{receptor} = PPV_{source}\,(25/d)^{1.5}$$

Where:

- PPV_{source} is the total vibration level at 25 feet (in/sec); and
- d is the distance from the equipment to the receptor (ft).

Vibration levels expressed as VdB are treated similarly to noise levels. Equation 10 was used to calculate the total L_v from all construction equipment. The equivalent L_v at the receptor was calculated using Equation 11.

Equation 10:

$$L_{v\_total} = 20 \log_{10} \Sigma\, 10^{(Lv\_equipment/20)}$$

Equation 11:

$$L_{v\_receptor} = L_{v\_source} - 30 \log_{10} (d/25)$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

Vibration levels associated with blasting are site-specific and are dependent on the amount of explosive used, soil conditions between the blast site and the receptor, and the elevation where blasting would take place (specifically, the below surface elevation where bedrock would be encountered). Blasting below the surface would produce lower vibration levels at a receptor due to additional attenuation provided by distance and transmission through soil and rock. Vibration from blasting was estimated using the Blast Vibration Prediction Curves published by L.L. Oriard in 1999 and 2000 (Caltrans 2004). One can estimate the PPV of blasting based on the square root scaled distance (Equation 12). The estimated PPV was converted to L_v using Equation 13. Actual blasting procedures would be dictated by site-specific conditions as determined by the construction contractor prior to construction and through monitoring during construction.

Equation 12:

$$D_s = d \, / \, \sqrt[3]{W}$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet); and
- W is the charge weight (pounds).

Equation 13:

$$L_v = 20 \, Log_{10}(PPV/10^6) - 12 \text{ (assuming a crest factor of 4)}$$

Calculated PPV and L_v were compared against the criteria of 0.3 in/sec and 72 VdB, respectively, to determine significance.

U.5 Construction-Related Traffic Noise Impact Assessment Methodology

Peak hour traffic noise levels for the Existing, No-Action, and Action Alternatives were estimated for construction workers' commuting vehicles, delivery trucks, and trucks hauling waste materials using the FHWA Traffic Noise Model, Version 2.5 (TNM2.5). TNM2.5 is capable of modeling noise impacts from automobiles, medium trucks (2 axles), heavy trucks (3 or more axles), buses, and motorcycles factoring in vehicle volume, vehicle speed, roadway configuration, distance to the noise-sensitive receptors, atmospheric absorption, and ground attenuation characteristics (FHWA, 1998a and 2004a). The model is based on measurements collected by the Volpe National Transportation Systems Center Acoustics Facility and is generally considered to be accurate within +/- 3 dB (FHWA, 1998b).

To simplify the analysis, bus and motorcycle volumes were assumed to be negligible and attenuation from the natural terrain and vegetation were not included. It was assumed that there would be equal volumes of traffic on each direction of a roadway and peak hour traffic coincides with the worst 1-hour L_{eq}. Peak hour noise levels were modeled for generic receptors 50 and 500 feet from the edge of the road. Fifty feet represents the minimum possible distance for a receptor along any roadway, and 500 feet is the maximum recommended receptor distance for traffic noise models (Caltrans, 2006). The modeled roadway segment should be longer than eight times the maximum source to receptor distance (FHWA 2004b). The maximum distance between the source and receptor is 500 feet; therefore an approximately 5,000 ft road segment was modeled.

Average daily traffic (ADT) counts published by ODOT (2010) and Caltrans (2010) provided the basis for estimating the existing noise levels on OR 66, US 97, and I-5. Existing 1-hr L_{eq} for Topsy Grade Road and Copco Road and vehicle distributions were provided by the transportation engineers (J. Key, personal communication, December 13, 2010). Based on a review of published ODOT and Caltrans traffic counts, peak hour traffic (PHT) volume was typically 10 to 20 percent of the average daily traffic volume. Changes in noise levels would be greater when the baseline traffic counts are lower; therefore for a conservative analysis, the analysis assumed that PHT is 10 percent of ADT. As free-flow speeds were not available, posted speed limits were entered in the model to be conservative. Because measured traffic counts on I-5 between Yreka and Anderson, California are generally higher than those north of Yreka, significance for the Yreka-Anderson segment was based on the significance of the segment north of Yreka, California. Traffic counts and characteristics of Topsy Grade Road was used to model noise levels on Ager-Beswick Road. It was assumed that there would be no increase in regional traffic between Existing Conditions and No-Action Alternative.

Under the Proposed Action, trucks would haul recyclable metal waste to Weed, California for waste originating in California and to Klamath Falls, Oregon for waste originating in Oregon. Wood waste from Copco 2 Dam would likely be hauled to a hazardous waste landfill in Anderson, CA. For construction of fish passages, rebar and wood would be supplied from Medford, OR, and concrete would be transported from Yreka, CA. The haul routes would likely be I-5, US 97, OR 66, Copco Road, Topsy Grade Road, and Ager-Beswick Road. Details regarding the roadways affected by this Proposed Action are presented in the Transportation Section (Section 3.22, Traffic and Transportation). The greater of the number of trucks available for each material or the peak daily haul truck volumes divided by 8 was used as the hourly truck volume. The estimated shift length is 8 hours. The hourly truck volumes were added to the existing/no-action peak hour traffic volumes. This analysis assumes that off-site hauling to suppliers and disposal areas would only occur during the daytime. All new truck trips are assumed to consist of heavy trucks, those with 3 axles or greater for use in the TNM2.5 model.

Construction workers would commute from Yreka, California or Medford, Oregon to Iron Gate, Copco 1, and Copco 2 sites and from Keno or Klamath Falls, Oregon to the J.C. Boyle site according to the Population and Housing Section (Section 3.17, Population and Housing). Maximum number of construction workers for J.C. Boyle was added to automobile traffic on US 97, OR 66, and Topsy Grade Road. Maximum total construction workers for Iron Gate, Copco 1, and Copco 2 were added to automobile traffic volume on Copco Rd and I-5. Because the distribution of workers from Medford, Oregon and Yreka, California on I-5 are unknown, maximum number of workers commuting to the California dams were added to both segments of I-5 for a conservative analysis.

For Alternatives 2, 3, and 5, truck and commute trips for all dams using the same road were combined. For Alternative 4, the maximum number of trucks and passenger vehicles traveling each road was used because construction is scheduled to occur one dam at a time.

Significance is defined as an increase of 12 dBA in California (Caltrans 2006) or 10 dBA in Oregon (ODOT 2009) or more above existing 1-hour Leq for traffic-induced noise.

The results of the traffic noise modeling analysis are presented in Attachment 3.

U.6 References

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Attachment 1

Construction Noise Impact Analysis

Table U1A. Copco 1 Dam and Powerhouse - Peak Day Construction Equipment Noise Level

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	4	83
Hoe ram	83	1	83
Articulated wheel loader	75	2	78
Dump truck	73	2	76
Pick-up truck	71	4	77
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Air compressor	74	4	80
Drill	74	4	80
Submersible pump	78	2	81
Blast	74	9	84
		TOTAL	91

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 2

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	1	77
Pick-up truck	71	4	77
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Air compressor	74	4	80
Drill	74	4	80
Submersible pump	78	2	81
		TOTAL	88

Fish Passage at Four Dams

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	4	79
Excavator	77	1	77
Hoe ram	83	1	83
Articulated wheel loader	75	1	75
Dump truck	73	1	73
Crawler dozer	77	1	77
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Concrete mixer	75	6	83
Concrete pump truck	74	1	74
Compactor	76	1	76
Engine generator	78	1	78
Portable generator	70	2	73
Air compressor	74	2	77
Drill	74	1	74
Submersible pump	78	2	81
		TOTAL	90

Calculations based on FHWA Roadway Construction Noise Model.

Table U1B. Attenuation Calculations for Copco 1 Receptor

Receptor Name	Residence on Janice Ave	
Distance from Source to Receptor	2200 ft	
Total Attenuation for Receptor	39 dB	$A_{total} = A_{div} + A_{air} + A_{ground} + IL_{topography}$

Distance Attenuation

Divergence (A_{div}, dB)	33	A_{div} = 20 x log(d/50)

Atmospheric Attenuation

Assumptions		
Ambient pressure (kPa)	101.3	
Average temperature (F)	50	
Relative humidity (%)	50	
Frequency of noise source (Hz)	500	
Air Attenuation Coefficient (α, dB/km)	1.9	
(dB/ft)	0.0006	
Atmospheric Attenuation (A_{air}, dB)	1.3	A_{air} = αd

Conversion:	0.3048	m/ft
	1000	m/km

<u>Weather in Montague, CA</u>

Average temperature	51
Average relative humidity	60%

Ground Attenuation

Parameters		
Source Height (hs, ft)	5	
Receptor Height (hr, ft)	5	
ds	150	ds = 30 x hs
dm	1,900	between ds and dr
dr	150	dr = 30 x hr
Ground Factor at Source (Gs)	0	Ground type G
Ground Factor at Receptor (Gr)	0	Hard 0
Ground Factor in the Middle (Gm)	0.4	Soft 1
As	-1.5	As = (6.5 x G) - 1.5
Ar	-1.5	Ar = (6.5 x G) - 1.5
Am	-1.6	
Ground Attenuation (A_{ground}, dB)	0.0	A_{ground} = As + Ar + Am

Assume 500 Hz.

Terrain Attenuation

Parameters		
Distance from source to apex of hill (d1, ft)	502	
Distance from receptor to apex of hill (d2, ft)	1700	
Distance from source to receptor (d, ft)	2,200	
Speed of Sound (ft/sec)	1126	
Frequency (Hz)	500	
Wavelength (λ)	2.25	
Fresnel Number (N)	2.4	N = (2 / λ) x [d1 + d2 - d]
Atmospheric Correction (K)	0.00	K = exp[-0.0005 √[(d1 x d2 x d) / (N x λ)]]
Topographic Attenuation (dB)	5	IL = 10 x log[3 + 10 x N x K] - A_{ground}

Reference:
Harris, Cyril M. 1998. Handbook of Acoustical Measurements and Noise Control. 3rd ed. - Chapter 3 Calculation of Attenuation
Weather in Montague, CA. http://qwikcast.weatherbase.com/weather/weatherall.php3?s=88057&refer

Table U1C. Receptor Noise Level from Construction Activities at the Copco 1 Dam and Powerhouse

Alternative	Project 1-hr Leq at Receptor (dBA)	Above Existing (dBA)
Proposed Action	49-52	10-22
Partial Removal	49-52	10-22
Fish Passage at 4 Dams	52	12
Fish Passage at 2 Dams	49-52	10-22
Criteria	N/A	10

Proposed Alternative; Partial Removal Alternative; Fish Passage at Two Dams, Remove Two Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	91	52	22
7:00	40	91	52	12
8:00	40	91	52	12
9:00	40	91	52	12
10:00	40	91	52	12
11:00	40	0	40	0
12:00	40	91	52	12
13:00	40	91	52	12
14:00	40	91	52	12
15:00	40	88	50	10
16:00	40	88	50	10
17:00	40	88	50	10
18:00	40	0	40	0
19:00	40	88	50	10
20:00	40	88	50	10
21:00	40	88	50	10
22:00	30	88	49	19
23:00	30	88	49	19

Assume one-hour breaks for construction workers at 11:00 and 18:00.

Fish Passage at Four Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	90	52	12
8:00	40	90	52	12
9:00	40	90	52	12
10:00	40	90	52	12
11:00	40	0	40	0
12:00	40	90	52	12
13:00	40	90	52	12
14:00	40	90	52	12
15:00	40	90	52	12
16:00	40	0	40	0
17:00	40	0	40	0
18:00	40	0	40	0
19:00	40	0	40	0
20:00	40	0	40	0
21:00	40	0	40	0
22:00	30	0	30	0
23:00	30	0	30	0

Assume a one-hour break for construction workers at 11:00.

Table U1D. Iron Gate Dam and Powerhouse - Peak Day Construction Equipment Noise Level

Proposed Action; Partial Facilities Removal; Remove Two Dams (per shift)

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	4	83
Dump truck	73	20	86
Crawler dozer	77	2	80
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Submersible pump	78	4	84
		TOTAL	91

Fish Passage at Four Dams

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	4	79
Excavator	77	1	77
Hoe ram	83	1	83
Articulated wheel loader	75	1	75
Dump truck	73	2	76
Crawler dozer	77	1	77
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Concrete mixer	75	4	81
Concrete pump truck	74	1	74
Compactor	76	1	76
Engine generator	78	3	82
Portable generator	70	2	73
Air compressor	74	2	77
Drill	74	2	77
Submersible pump	78	2	81
		TOTAL	91

Calculations based on FHWA, Roadway Construction Noise Model, January 2006.

Table U1E. Attenuation Calculations for Iron Gate Receptor

Receptor Name	Residence on Tarpon Drive	
Distance from Source to Receptor	4500 ft	
Total Attenuation for Receptor	46 dB	$A_{total} = A_{div} + A_{air} + A_{ground} + IL_{topography}$

Distance Attenuation

Divergence (A_{div}, dB)	39	A_{div} = 20 x log(d/50)

Atmospheric Attenuation

Assumptions		
Ambient pressure (kPa)	101.3	
Average temperature (F)	50	
Relative humidity (%)	50	
Frequency of noise source (Hz)	500	
Air Attenuation Coefficient (α, dB/km)	1.9	
(dB/ft)	0.0006	
Atmospheric Attenuation (A_{air}, dB)	2.6	A_{air} = αd

Conversion:	0.3048	m/ft
	1000	m/km

Weather in Montague, CA	
Average temperature	51
Average relative humidity	60%

Ground Attenuation

Parameters		
Source Height (hs, ft)	5	
Receptor Height (hr, ft)	5	
ds	150	ds = 30 x hs
dm	4,201	between ds and dr
dr	150	dr = 30 x hr
Ground Factor at Source (Gs)	0	Ground type G
Ground Factor at Receptor (Gr)	1	Hard 0
Ground Factor in the Middle (Gm)	0.4	Soft 1
As	-1.5	As = (6.5 x G) - 1.5
Ar	5	Ar = (6.5 x G) - 1.5
Am	-1.7	
Ground Attenuation (A_{ground})	2	A_{ground} = As + Ar + Am

Assume 500 Hz.

Terrain Attenuation

Parameters		
Distance from source to apex of hill (d1, ft)	1600	
Distance from receptor to apex of hill (d2, ft)	2901	
Distance from source to receptor (d, ft)	4,501	
Speed of Sound (ft/sec)	1126	
Frequency (Hz)	500	
Wavelength (λ)	2.25	
Fresnel Number (N)	0.2	N = (2 / λ) x [d1 + d2 - d]
Atmospheric Correction (K)	0.00	K = exp[-0.0005 √[(d1 x d2 x d) / (N x λ)]]
Topographic Attenuation (dB)	3	IL = 10 x log[3 + 10 x N x K] - A_{ground}

Reference:

Harris, Cyril M. 1998. Handbook of Acoustical Measurements and Noise Control. 3rd ed. - Chapter 3 Calculation of Attenuation
Weather in Montague, CA. http://qwikcast.weatherbase.com/weather/weatherall.php3?s=88057&refer

Table U1F. Receptor Noise Level from Construction Activities at the Iron Gate Dam and Powerhouse

Alternative	Project 1-hr Leq at Receptor (dBA)	Above Existing (dBA)
Proposed Action	44-46	6-14
Partial Removal	44-46	6-14
Fish Passage at 4 Dams	46	6
Fish Passage at 2 Dams	44-46	6-14
Criteria	N/A	10

Proposed Alternative; Partial Removal Alternative; Fish Passage at Two Dams, Remove Two Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	91	46	6
8:00	40	91	46	6
9:00	40	91	46	6
10:00	40	91	46	6
11:00	40	0	40	0
12:00	40	91	46	6
13:00	40	91	46	6
14:00	40	91	46	6
15:00	40	91	46	6
16:00	40	91	46	6
17:00	40	91	46	6
18:00	40	91	46	6
19:00	40	0	40	0
20:00	40	91	46	6
21:00	40	91	46	6
22:00	30	91	44	14
23:00	30	0	30	0

Assume one-hour breaks for construction workers at 11:00 and 19:00.

Fish Passage at Four Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	91	46	6
8:00	40	91	46	6
9:00	40	91	46	6
10:00	40	91	46	6
11:00	40	0	40	0
12:00	40	91	46	6
13:00	40	91	46	6
14:00	40	91	46	6
15:00	40	91	46	6
16:00	40	0	40	0
17:00	40	0	40	0
18:00	40	0	40	0
19:00	40	0	40	0
20:00	40	0	40	0
21:00	40	0	40	0
22:00	30	0	30	0
23:00	30	0	30	0

Assume a one-hour break for construction workers at 11:00.

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Attachment 2

Construction Vibration Impact Analysis

Table U2A. Copco 1 Dam and Powerhouse - Peak Day Construction Equipment Vibration Level

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0005	42
Excavator	4	0.356	99	0.0004	41
Hoe ram	1	0.089	87	0.0001	29
Articulated wheel loader	2	0.178	93	0.0002	35
Dump truck	2	0.152	92	0.0002	34
Pick-up truck	4	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Engine generator	2	0	0	0.0000	0
Air compressor	4	0	0	0.0000	0
Drill	4	0.14	91	0.0002	33
Submersible pump	2	0	0	0.0000	0
TOTAL without blasting	N/A	1.40	111	0.002	53
Blast	9	N/A	N/A	0.0630	84
TOTAL with blasting	N/A	N/A	N/A	0.065	84

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0005	42
Excavator	1	0.089	87	0.0001	29
Pick-up truck	4	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Engine generator	2	0	0	0.0000	0
Air compressor	4	0	0	0.0000	0
Drill	4	0.14	91	0.0002	33
Submersible pump	2	0	0	0.0000	0
TOTAL		0.71	105	0.001	47

Fish Passage at Four Dams

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	4	0.808	106	0.0010	48
Excavator	1	0.089	87	0.0001	29
Hoe ram	1	0.089	87	0.0001	29
Articulated wheel loader	1	0.089	87	0.0001	29
Dump truck	1	0.076	86	0.0001	28
Crawler dozer	1	0.089	87	0.0001	29
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Concrete mixer	6	0.456	102	0.0006	44
Concrete pump truck	1	0.076	86	0.0001	28
Compactor	1	0.21	94	0.0003	36
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	1	0.035	79	0.0000	21
Submersible pump	2	0	0	0.0000	0
TOTAL		2.09	115	0.0025	57

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2B. Copco 2 Dam - Peak Day Construction Equipment Vibration Level

Proposed Action

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	2	0.178	93	0.0001	28
Hoe ram	2	0.178	93	0.0001	28
Articulated wheel loader	3	0.267	97	0.0001	32
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Engine generator	5	0	0	0.0000	0
Air compressor	3	0	0	0.0000	0
Drill	4	0.14	91	0.0001	26
Submersible pump	5	0	0	0.0000	0
TOTAL		1.69	113	0.0009	48

Partial Removal

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	2	0.178	93	0.0001	28
Hoe ram	2	0.178	93	0.0001	28
Articulated wheel loader	3	0.267	97	0.0001	32
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Engine generator	5	0	0	0.0000	0
Air compressor	3	0	0	0.0000	0
Drill	3	0.105	89	0.0001	24
Submersible pump	5	0	0	0.0000	0
TOTAL		1.65	113	0.0009	48

Fish Passage at Four Dams; Fish Passage at Two Dams

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	1	0.089	87	0.0000	22
Hoe ram	1	0.089	87	0.0000	22
Articulated wheel loader	1	0.089	87	0.0000	22
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	2	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Concrete mixer	3	0.228	96	0.0001	31
Concrete pump truck	1	0.076	86	0.0000	21
Compactor	1	0.21	94	0.0001	29
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	1	0.035	79	0.0000	14
Submersible pump	2	0	0	0.0000	0
TOTAL		1.74	113	0.0010	48

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2C. Iron Gate Dam and Powerhouse - Peak Day Construction Equipment Vibration Level

Proposed Action; Partial Facilities Removal; Remove Two Dams (per shift)

		At Source 25 ft		At Receptor 4500 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0002	32
Excavator	4	0.356	99	0.0001	31
Dump truck	20	1.52	112	0.0006	44
Crawler dozer	2	0.178	93	0.0001	25
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	18
Engine generator	2	0	0	0.0000	0
Submersible pump	4	0	0	0.0000	0
TOTAL		2.53	116	0.0010	48

Fish Passage at Four Dams

		At Source 25 ft		At Receptor 4500 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	4	0.808	106	0.0003	38
Excavator	1	0.089	87	0.0000	19
Hoe ram	1	0.089	87	0.0000	19
Articulated wheel loader	1	0.089	87	0.0000	19
Dump truck	2	0.152	92	0.0001	24
Crawler dozer	1	0.089	87	0.0000	19
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	18
Concrete mixer	4	0.304	98	0.0001	30
Concrete pump truck	1	0.076	86	0.0000	18
Compactor	1	0.21	94	0.0001	26
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	2	0.07	85	0.0000	17
Submersible pump	2	0	0	0.0000	0
TOTAL		2.05	114	0.0008	46

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2D. Summary of Vibration Levels from Construction Equipment

	Total Equipment Peak Particle Velocity (in/sec) for each Alternative				
Source Location	**Full Removal Alternative**	**Partial Removal Alternative**	**Fish Passage at Four Dams**	**Fish Passage at Two Dams**	**Significance Criteria**
Copco1	0.063	0.063	0.003	0.063	0.3
Copco 2	0.001	0.001	0.001	0.001	0.3
Iron Gate	0.001	0.001	0.001	0.001	0.3

	Total Equipment Ground-Vibration (VdB) for Each Alternative				
Source Location	**Full Removal Alternative**	**Partial Removal Alternative**	**Fish Passage at Four Dams**	**Fish Passage at Two Dams**	**Significance Criteria**
Copco1	84	84	53	84	72
Copco 2	44	44	46	46	72
Iron Gate	40	40	43	40	72

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Attachment 3

Traffic Noise Impact Analysis

Table U3A. Estimated Traffic Counts for Existing Conditions

Road Segment	AADT	AADT Distribution (%) [1]			AADT Distribution			PHT Distribution [3]			PHT Distribution for Each Direction [4]		
		Auto [2]	Medium Trucks [2]	Heavy Trucks [2]	Auto	Medium Trucks	Heavy Trucks	Auto	Medium Trucks	Heavy Trucks	Auto	Medium Trucks	Heavy Trucks
Topsy Grade Rd [5]	200	58.82	34.85	6.33	118	70	13	12	7	2	6	4	1
OR 66 [6]	500	58.82	34.85	6.33	294	174	32	29	17	3	15	9	2
US 97 [7]	6300	33.55	28.34	38.11	2114	1785	2401	211	179	240	106	90	120
Ager-Beswick Rd [8]	200	58.82	34.85	6.33	117.64	69.7	12.66	12	7	2	6	4	1
Copco Rd [5]	250	71.34	0	28.66	178	0	72	18	0	7	9	0	4
I-5 (Oregon) [9]	24400	69.45	17.56	12.99	16946	4285	3170	1695	428	317	848	214	159
I-5 (California) [10]	15200	71.34	0	28.66	10844	0	4356	1084	0	436	542	0	218

Notes:

[1] AADT distribution percentage provided by transportation engineers (J. Key, personal communication, December 13, 2010).

[2] TNM vehicle classification: Auto = cars and light duty trucks, Medium Trucks = cargo vehicles with two axles and six tires; Heavy trucks - cargo vehicles with three or more axles.

[3] PHT assumed to be 10% of AADT based on a review of published Caltrans and ODOT traffic counts (ODOT, 2010; Caltrans, 2010).

[4] PHT for each direction assumed to be the same in both direction of traffic.

[5] Traffic count estimated from field observations (CDM, field observations, October 17, 2010).

[6] AADT at MP 48.73, 0.02 mile east of Hamaker Mountain Road (ODOT, 2010).

[7] AADT at MP 273.92, 0.30 mile south of Nevada Avenue Interchange (ODOT, 2010).

[8] Assume Ager-Beswick Rd is similar to Topsy Grade Rd (J. Key, personal communication, February 8, 2011).

[9] AADT at MP18.60, 0.50 mile south of North Ashland Interchange (ODOT, 2010).

[10] Lowest AADT measured along I-5 in 2009 between Copco Rd and Oberlin Rd; MP 61.553 at Henley Way (Caltrans, 2010).

Table U3B. Characteristics of Roads Analyzed for Hauling and Worker Commute Noise Impact

Road Segment	Total Number of Lanes	Width (feet)			Modeled Speed
		North/Eastbound Lanes	Median	SB/WB	
Topsy Grade Road	2	12	0	12	35
US 97	2	12	0	12	65
I-5 (Oregon)	4	25	100	25	65
OR 66	2	12	0	12	55
I-5 (California)	4	25	70	25	70
Copco Road	2	12	0	12	55
Ager-Beswick Road	2	12	0	12	35

Source: J. Key, personal communication, December 29, 2010 and February 8, 2011

Table U3C. Maximum Estimated Number of Construction Workers

	Number of Workers			
Dam	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
J.C. Boyle	45	41	20	20
Copco 1 (day)	36	36	25	36
Copco 1 (night)	20	20	N/A	20
Copco 2	40	38	20	20
Iron Gate (day)	40	40	30	40
Iron Gate (night)	40	40	N/A	40
CA Dams Subtotal (day)	116	114	75	96
CA Dams Subtotal (night)	60	60	0	60

Alternative 4

Road Segment	Direction	JC Boyle	Copco 1	Copco 2	Iron Gate	Maximum
Topsy Grade Rd	North	0	0	0	0	0
	South	20	0	0	0	20
OR 66	East	0	0	0	0	0
	West	20	0	0	0	20
US 97	North	0	0	0	0	0
	South	20	0	0	0	20
Ager Rd	North	0	0	0	0	0
	South	0	0	0	0	0
Copco Rd	East	0	25	20	30	30
	West	0	0	0	0	0
I-5 (Oregon)	North	0	0	0	0	0
	South	0	25	20	30	30
I-5 (California)	North	0	25	20	30	30
	South	0	0	0	0	0

		Number of Commuters per Hour			
Road Segment	**Direction**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Topsy Grade Rd	North	0	0	0	0
	South	45	41	20	20
OR 66	East	0	0	0	0
	West	45	41	20	20
US 97	North	0	0	0	0
	South	45	41	20	20
Ager Rd	North	0	0	0	0
	South	0	0	0	0
Copco Rd	East	116	114	30	96
	West	0	0	0	0
I-5 (Oregon)	North	0	0	0	0
	South	116	114	30	96
I-5 (California)	North	116	114	30	96
	South	0	0	0	0

Assume all construction workers arrive within an hour.
Assumption from Population and Housing Section:
- Workers for JC Boyle assumed to commute from Klamath Falls, via US 97, OR 66, and Topsy Grade Rd.
- Workers for Iron Gate & Copco facilities assumed to commute from Medford and Yreka, via I-5 and Copco Rd.

Alt 4 construction at each dam occurs in a different year, therefore, the maximum worker travel on each road is used.

Table U3D. Peak Hourly Off-Site Haul Trucks

Dam	Destination	Origin	Alt 2 Peak Daily		Alt 3 Peak Daily		Alt 4 Peak Daily		Alt 5 Peak Daily	
			Units	Trips	Units	Trips	Units	Trips	Units	Trips
J.C. Boyle	Klamath Falls		4	20	2	10	0	0	0	0
		Medford	0	0	0	0	2	2	2	2
		Yreka	0	0	0	0	2	9	2	9
Copco 1		Medford	0	0	0	0	2	2	0	0
		Yreka	0	0	0	0	2	9	0	0
	Yreka		2	10	1	5	0	0	2	10
Copco 2		Medford	0	0	0	0	2	2	2	2
		Yreka	0	0	0	0	2	9	2	9
	Yreka		5	25	3	15	0	0	0	0
	Anderson		1	2	1	2	0	0	0	0
Iron Gate		Medford	0	0	0	0	2	2	0	0
		Yreka	0	0	0	0	2	9	0	0
	Yreka		2	10	1	5	0	0	2	10

Dam	Destination	Origin	Peak Hourly Trucks				Road Segments						
			Alt 2	Alt 3	Alt 4	Alt 5	Topsy Grade	OR 66	US 97	Ager	Copco	I-5 (OR)	I-5 (CA)
J.C. Boyle	Klamath Falls		4	4	0	0	North	East	North				
		Medford	0	0	2	2	South	East				South	
		Yreka	0	0	2	2	South	East					North
Copco 1		Medford	0	0	2	0					East	South	South
		Yreka	0	0	2	0				North			
	Yreka		2	1	0	2					West		South
Copco 2		Medford	0	0	2	2					East	South	South
		Yreka	0	0	2	2				North			
	Yreka		5	3	0	0					West		South
	Anderson		1	1	0	0				South			South
Iron Gate		Medford	0	0	2	0					East	South	South
		Yreka	0	0	2	0					East		North
	Yreka		2	1	0	2					West		South

Unless the number of trips divided by the number of units is greater than 8 (construction shift length), peak daily units is used as the peak hourly trucks.

Assumed single truck makes maximum two trips to Klamath Falls from J.C. Boyle in Alt 3.

		Number of Heavy Trucks per Hour			
Road Segment	Direction	Alt 2	Alt 3	Alt 4	Alt 5
Topsy Grade Rd	North	4	4	0	0
	South	0	0	4	4
OR 66	East	4	4	4	4
	West	0	0	0	0
US 97	North	4	4	0	0
	South	0	0	0	0
Ager Rd	North	0	0	2	2
	South	1	1	0	0
Copco Rd	East	0	0	4	2
	West	9	5	0	4
I-5 (Oregon)	North	0	0	0	0
	South	0	0	2	4
I-5 (California)	North	0	0	2	2
	South	10	6	2	6

Alternative 4

		Number of Heavy Trucks per Hour				
Road Segment	Direction	JC Boyle	Copco 1	Copco 2	Iron Gate	Maximum
Topsy Grade Rd	North	0	0	0	0	0
	South	4	0	0	0	4
OR 66	East	4	0	0	0	4
	West	0	0	0	0	0
US 97	North	0	0	0	0	0
	South	0	0	0	0	0
Ager Rd	North	0	2	2	0	2
	South	0	0	0	0	0
Copco Rd	East	0	2	2	4	4
	West	0	0	0	0	0
I-5 (Oregon)	North	0	0	0	0	0
	South	2	2	2	2	2
I-5 (California)	North	2	0	0	2	2
	South	0	2	2	2	2

Alt 4 construction at each dam occurs in a different year, therefore, the maximum truck travel on each road is used.

Table U3E. Estimated Peak Hour Traffic Counts per Direction

Road Segment	Direction	Existing Conditions [1]			Proposed Action			Partial Removal			Fish Passage			Remove Two Dams		
		Auto [2]	Medium Trucks [2]	Heavy Trucks [2]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]
Topsy Grade Rd [4]	North	6	4	1	6	4	5	6	4	5	6	4	1	6	4	1
	South	6	4	1	51	4	1	47	4	1	26	4	5	26	4	5
OR 66 [4]	East	15	9	2	15	9	6	15	9	6	15	9	6	15	9	6
	West	15	9	2	60	9	2	56	9	2	35	9	2	35	9	2
US 97 [4]	North	106	90	120	106	90	124	106	90	124	106	90	120	106	90	120
	South	106	90	120	151	90	120	147	90	120	126	90	120	126	90	120
Ager Rd	North	6	4	1	6	4	1	6	4	1	6	4	3	6	4	3
	South	6	4	1	6	4	2	6	4	2	6	4	1	6	4	1
Copco Rd [5]	East	9	0	4	125	0	4	123	0	4	39	0	8	105	0	6
	West	9	0	4	9	0	13	9	0	9	9	0	4	9	0	8
I-5 (Oregon) [5]	North	848	214	159	848	214	159	848	214	159	848	214	159	848	214	159
	South	848	214	159	964	214	159	962	214	159	878	214	161	944	214	163
I-5 (California) [5]	North	542	0	218	658	0	218	656	0	218	572	0	220	638	0	220
	South	542	0	218	542	0	228	542	0	224	542	0	220	542	0	224

Notes:

[1] See Existing Conditions table for PHT distribution references.

[2] TNM vehicle classification: Auto = cars and light duty trucks, Medium Trucks = all cargo vehicles with two axles and six tires; Heavy trucks - all cargo vehicles with three or more axles.

[3] All haul trucks assumed to be Heavy Trucks (3 axles or more).

[4] Workers for J.C. Boyle assumed to travel from Klamath Falls. Maximum number of construction workers for J.C. Boyle added to the Auto category for Topsy Grade Rd, OR 66, and US 97

[5] Workers for Iron Gate, Copco 1, and Copco 2 assumed to travel from Medford or Yreka. Maximum number of construction workers for the three facilities added to the Auto category for Copco Rd and I-5. Construction workers are double counted in the Oregon and California segments of I-5 for conservative estimate.

Table U3F. 1-Hr Leq Noise Levels Near Roadways (dBA)

Road Segment	Existing / No Action (Baseline)		Proposed Action		Partial Removal		Fish Passage at Four Dams		Fish Passage at Two Dams	
	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft
Topsy Grade Rd	53	42	56	45	Less impact than Alt 2		56	44	56	44
OR 66	60	49	62	51			62	50	62	50
US 97	75	64	76	64			76	64	76	64
Ager Rd	53	42	54	43			54	43	53	42
Copco Rd	58	46	63	51			60	49	62	51
I-5 (Oregon)	77	66	77	66			77	66	77	66
I-5 (California)	76	66	77	66			77	66	77	66

Increase in 1-Hr Leq Noise Level Above Existing Conditions (dBA)

Road Segment	Significance Criteria (dBA)		Proposed Action		Partial Removal		Fish Passage at Four Dams		Fish Passage at Two Dams	
			50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft
Topsy Grade Rd	OR	10	3	3	Less impact than Alt 2		3	3	3	3
OR 66	OR	10	2	2			1	1	1	1
US 97	OR	10	0	0			0	0	0	0
Ager Rd	CA	12	1	1			3	3	0	0
Copco Rd	CA	12	5	5			2	2	4	4
I-5 (Oregon)	OR	10	0	0			0	0	0	0
I-5 (California)	CA	12	0	0			0	0	0	0

The increase in Leq may appear different when subtracting the existing 1-hour Leq from project 1-hour Leq values due to rounding.

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