EXHIBIT E—ENVIRONMENTAL REPORT

Klamath Hydroelectric Project
(FERC Project No. 2082)

Water Use and Quality

PacifiCorp
Portland, Oregon

Version: February 2004

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E3.0 WATER USE AND QUALITY

This section of the Klamath Hydroelectric Project (Federal Energy Regulatory Commission [FERC] Project No. 2082) Exhibit E provides a report on water use and quality potentially affected by the Project as stipulated in the U.S. Code of Federal Regulations (CFR) Title 18 Section 4.51(f)(2):

The report must discuss the consumptive use of project waters and the impact of the project on water quality. The report must be prepared in consultation with the state and Federal agencies with responsibility for management of water quality in the affected stream or other body of water. Consultation must be documented by appending to the report a letter from each agency consulted that indicates the nature, extent, and results of the consultation. The report must include:

(i) A description (including specified volume over time) of existing and proposed uses of project waters for irrigation, domestic water supply, steam-electric plant, industrial, and other consumptive purposes

(ii) A description of existing water quality in the project impoundment and downstream water affected by the project and the applicable water quality standards and stream segment classifications

(iii) A description of any minimum flow releases specifying the rate of flow in cubic feet per second (cfs) and duration, changes in the design of project works or in project operation, or other measures recommended by the agencies consulted for the purposes of protecting or improving water quality, including measures to minimize the short-term impacts on water quality of any proposed new development of project works (for any dredging or filling, refer to 40 CFR part 230 and 33 CFR 320.3(f) and 323.3(e))\1\;[*Note:* \1\ 33 CFR part 323 was revised as 47 FR 31810, July 22, 1982, and Sec. 323.3(e) no longer exists.]

(iv) A statement of the existing measures to be continued and new measures proposed by the PacifiCorp for the purpose of protecting or improving water quality, including an explanation of why the PacifiCorp has rejected any measures recommended by an agency and described under paragraph (f)(2)(iii) of this section

(v) A description of the continuing impact on water quality of continued operation of the project and the incremental impact of proposed new development of project works or changes in project operation

In the course of study and in the interim between the draft license application and this final application, PacifiCorp made a few changes to the proposed Project. The newly proposed Project begins at the J.C. Boyle Development and continues downstream to the Iron Gate Development. The Spring Creek diversion is now included in the Fall Creek Development. The East Side, West Side, and Keno Developments are no longer part of the Project. Keno dam will remain in operation, but it is not included in the FERC Project because the development does not have generation facilities and its operation does not substantially benefit generation at PacifiCorp's downstream hydroelectric developments.

E3.1 EXISTING AND PROPOSED USES OF PROJECT WATERS

E3.1.1 Overview of Flow Regulation and Water Use in Project Vicinity

Upper Klamath Lake is the major source of water for PacifiCorp's Klamath Hydroelectric Project (Project). Mean net inflow to the lake is 1.2 million acre-feet (ac-ft); inflow ranges from 576,000 ac-ft to 2.4 million ac-ft (USBR, 1998). The lake has a total storage capacity of 629,780 ac-ft, but an operational capacity of 486,830 ac-ft.

Upper Klamath Lake and the Klamath River are also major sources of water for the U.S. Bureau of Reclamation (USBR) Klamath Irrigation Project. Water for the Klamath Irrigation Project is diverted from Upper Klamath Lake through the A canal (just upstream of the Link River dam) during the irrigation season (May-October). Agricultural returns from this diversion enter the Klamath River through the ADY canal just upstream of Keno dam. In the fall and winter, excess and irrigation drain water from the Lost River basin and Lower Klamath Lake (a closed system) are added to the total flow of the Klamath River upstream of Keno dam from the Lost River Canal.

USBR has management control of Upper Klamath Lake elevations and Iron Gate dam releases. This control by USBR of flows into, and out of, the Klamath Hydroelectric Project area, coupled with relatively small active storage in Project reservoirs, means that PacifiCorp's operations have little or no control over the river's flow regime, except on a short-term (hourly, daily) basis and at certain locations (described below). In the past, USBR set operational conditions that allowed PacifiCorp to efficiently use Upper Klamath Lake as a reservoir for hydroelectric service. Since about 1992, however, USBR has modified Link River dam operations to benefit the shortnose sucker and the Lost River sucker, two Klamath River basin fish listed in 1988 as endangered under the Endangered Species Act (ESA). To protect these fish, the U.S. Fish and Wildlife Service (USFWS) required that water levels in Upper Klamath Lake be managed within specific elevation limits. The impact to PacifiCorp was a loss of flexibility in how Upper Klamath Lake could be used to benefit power production and potentially an increased risk associated with springtime flooding. The overall result has been higher Upper Klamath Lake elevations and an increase in the amount of water spilled to the river in the spring owing to the reduction in lake storage that results from the higher elevations.

In 1996, PacifiCorp consulted with USFWS specific to the effect of Project operations on the two listed suckers. USFWS provided a Biological Opinion (BO) and an associated Incidental Take Statement containing terms and conditions that required PacifiCorp to invest in off-site habitat restoration on the Lower Williamson River property to benefit larval suckers and to conduct scientific studies to mitigate for Project impacts. The 1996 BO resulted in only minimal change to the Project's daily operations.

USBR's obligations under ESA initially included specific Upper Klamath Lake elevations to address the two listed sucker species, but since 1997 their obligations include specific flow releases at Iron Gate dam to address listing of coho salmon.[1] Since 1997, USBR has defined

[1] Southern Oregon and Northern California coho salmon were listed as a threatened species on May 6, 1997. The environmentally significant unit (ESU) includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, including the Klamath River. Critical habitat was designated on May 5, 1999, to include all river reaches accessible to listed coho salmon between Cape Blanco and Punta Gorda, including the Klamath River.

Klamath Irrigation Project operations through annual operations plans in consultation with the National Oceanic and Atmospheric Administration (NOAA-Fisheries) and USFWS. Each USBR annual plan defined how Upper Klamath Lake and flows downstream of Iron Gate dam would be regulated for that year, based on hydrological and environmental conditions. To assist USBR in achieving its plan and to address flows at Iron Gate dam potentially less than the flow stipulated by FERC, PacifiCorp has signed annual agreements with USBR stating that PacifiCorp will operate the Klamath Hydroelectric Project in accordance with the annual plan. USBR is currently operating under the Klamath Irrigation Project 2003 Operations Plan (April 10, 2003), and is engaged in the process of developing a long-term operation plan so that new plans do not have to be written each year.

To comply with ESA, PacifiCorp coordinates with USBR to pass through those minimum flows stated in the 2003 Operations Plan rather than those cited as the FERC minimum. During 2003 through 2005, USBR will meet or exceed minimum flow releases from Iron Gate dam as stipulated in the 2003 Operations Plan. These minimum flow releases from Iron Gate dam are described further in section E3.1.6. An additional volume will be provided by a water bank. Specifically, the minimum volume of additional water during water years 2003 through 2005 will be 50 total ac-ft, 75 total ac-ft, and 100 total ac-ft, respectively. The amount of this additional water is to increase with each successive year as USBR continues to develop water resources to support a reliable water bank. Iron Gate fish hatchery return water and Bogus Creek contributions are included in this minimum flow.

E3.1.1.1 Klamath River Mainstem Facilities

The existing PacifiCorp Klamath Hydroelectric Project consists of six hydroelectric power-generating facilities on the mainstem Klamath River. The uppermost stream developments, East Side and West Side, are associated with USBR’s Link River dam. The dam was constructed as a result of a 1917 agreement between PacifiCorp’s predecessor, Copco, and USBR to regulate flows out of Upper Klamath Lake. This agreement and a later renewed contract, the 1956 contract, gave Copco significant flexibility to regulate the active water storage in Upper Klamath Lake to maximize water availability for downstream hydroelectric generation outside the irrigation period. This flexibility remained largely intact until 1992, when the operation of Link River dam was restricted more significantly to protect ESA-listed threatened species. The new policies required certain Upper Klamath Lake levels be met, reducing the capability of Upper Klamath Lake to store spring flood flows. This has resulted in increased water spilled.

In 1996, due to these and downstream minimum flow requirements, and the related potential liability for ESA-related charges, PacifiCorp contemplated rescinding its 1956 operations contract with USBR. In 1997, an agreement was reached whereby USBR assumes all responsibility for Upper Klamath Lake levels and downstream flow requirements (below Iron Gate dam). This agreement means that PacifiCorp has no more than an average 7-day storage capacity (12,000 ac-ft) in its entire Project system. Under historical operations, the Project had some capacity for longer term (monthly, seasonal) storage to balance available water for hydropower by use of Upper Klamath Lake. Currently, with little or no control over storage in Upper Klamath Lake or downstream flows below Iron Gate dam, PacifiCorp only has the ability to influence flows at daily or hourly time steps within its Project area.

In late winter and spring, particularly for average or wetter years, Project reservoirs are typically full, resulting in run-of-river operations through the Project reach. In summer and fall, when average flows are below the capacity of the turbines, PacifiCorp will manage flows within the Project to maximize power generation. For example, this might typically involve holding half of the available inflow to a reservoir, filling the reservoir during the night, and releasing 1.5 times the available inflow during the day to increase the flow through the turbines during the time when electricity demand is relatively high. This results in a shift in time of 12 hours and a change in magnitude of 50 percent of the available inflow. Since the capacity of the turbines at the “peaking” facilities—J.C. Boyle, Copco No. 1, and Copco No. 2—are approximately 2,850 to 3,200 cfs, any larger flows would not be subject to this peaking action. Minimum instream flows and prescribed ramping rates also constrain this approach, based on FERC license requirements and ESA considerations. With instream flow requirements at Iron Gate dam typically at approximately 1,000 cfs or more, this effectively limits the range of possible operational effects to no more than +/- 2,000 cfs (3,000 cfs minus 1,000 cfs) from available inflow, within the 1,000- to 3,000-cfs range. Temporally, this maximum effect can only be in place for up to 3.5 days, assuming active storage is empty, before reservoirs would fill to run-of-river conditions. The largest impact of this peaking behavior is the wide fluctuation between high and low flow that can occur during a single day within reaches affected by peaking—i.e., the J.C. Boyle peaking reach between the J.C. Boyle powerhouse at river mile (RM) 200.4 and Copco reservoir (RM 204), and below Copco No. 2 powerhouse RM 196.8) whose tailwaters flow directly into the upper end of Iron Gate reservoir.

E3.1.1.2 Fall Creek Facility

The Fall Creek facility is located on Fall Creek, a tributary of the Klamath River, located approximately 0.4 mile south of the Oregon-California border. The Fall Creek facility consists of two small diversion dams, an earthen ditch, a penstock, and a powerhouse. The dams are on Fall Creek and Spring Creek. The Spring Creek dam has been in use periodically because of a water rights dispute. That water right is currently being adjudicated (see section E3.1.7 for more detailed information).

Built in 1903, the Fall Creek hydroelectric facility is one of PacifiCorp’s oldest. The dam on Fall Creek is a log crib, earth-filled diversion dam. The Fall Creek facility is operated for base load generation. It also provides the required minimum flow of 15 cfs downstream of the powerhouse. During periods of higher flow, water in excess of diversion capacity (50 cfs) passes over the diversion dam. Current FERC minimum flow requirements are 0.5 cfs at all times from the Fall Creek diversion dam into Fall Creek, and a 15-cfs continuous flow in Fall Creek (or a quantity equal to the natural flow of the stream, whichever is less) at the outlet of the powerhouse tailrace.

E3.1.2 Project Area’s Hydrologic Drainage Area and Flow Regime

The drainage basin area upstream from Iron Gate dam covers 4,630 square miles, extending throughout Klamath County, Oregon, and Siskiyou County, California. The drainage basin areas upstream from the J.C. Boyle powerhouse and Keno dam cover about 4,080 and 3,920 square miles, respectively, within Klamath County. However, the operations and diversions for irrigation and wildlife refuge maintenance from Upper Klamath Lake largely control drainage flows within the basin. Ninety-eight percent of the available 499,074 ac-ft of active storage on the Klamath River above Iron Gate dam is contained in Upper Klamath Lake.

Annual gauged runoff and seasonal flow patterns on the Klamath River generally reflect climatic conditions and cycles (Balance Hydrologics, 1996; Ayers Associates, 1999). Precipitation in the basin is distinctly seasonal, with 60 percent of the total annual precipitation falling from November to March. December and January are the wettest months; the driest months are between June and September. Annual precipitation patterns historically define distinct dry and wet cycles that are closely related to runoff and the river's flow regime. The most recent climatic trends include wet periods from 1885 to 1915 and 1940 to 1975, and dry periods from 1915 to 1940 and 1975 to 1994. General decreases in runoff and discharge over the last 20 years also coincide with a generally decreasing trend in precipitation patterns.

The installation of Copco No. 1 and No. 2 dams (1918 and 1925, respectively) followed by Link River dam (1921), J.C. Boyle dam (1958), Iron Gate dam (1962), and Keno dam (1967) have had an effect on storage capacity and flow in the Klamath River. In addition, extensive diversions in the upper basin include the A canal (1907), the Lost River diversion canal (1912), the North canal diversion, and the Klamath Straits Drain diversion.

As summarized in Table E3.1-1, the reservoirs in the upper basin currently are capable of storing about 50 percent of the mean annual flow at the Iron Gate gauge site. However, most of this storage (41 percent) is provided by Upper Klamath Lake, because the other reservoirs operated by PacifiCorp have a limited ability to store and therefore affect the Klamath River's overall flow regime. The ability of the reservoirs in the upper basin to alter the river's flow regime further diminishes with distance downstream. For example, the reservoirs are capable of storing about 6 percent of the mean annual runoff (MAR) at the U.S. Geological Survey (USGS) Klamath gauge site near the mouth of the Klamath River at Klamath, California, of which 5 percent is provided by Upper Klamath Lake (Table E3.1-1).

Table E3.1-1. Reservoir total storage capacities (ac-ft) as a percent of mean annual runoff (MAR) for facilities in the Upper Klamath River basin.

Dam/Reservoir	Year Completed	Reservoir Total Storage Capacity (ac-ft)	Storage Capacity (ac-ft) as a Percent of MAR at Two Gauge Sites*	
			Iron Gate Dam (RM 190)	**Klamath, California (RM 5)**
Copco No. 1	1918	46,867	3.0	0.4
Link/Upper Klamath Lake	1921	629,780	40.9	5.0
Copco No. 2	1925	73	<0.1	<0.1
J.C. Boyle	1958	3,495	0.2	<0.1
Iron Gate	1962	58,794	3.8	0.5
Keno	1967	18,500	1.2	0.1
Total		757,509	49.2	6.0

*USGS gauges: No. 11516530 downstream of Iron Gate dam (MAR = 2,125 cfs) and No. 11530500 at Klamath, California (MAR = 17,533 cfs).

As described in section E3.1.1, USBR's annual Klamath Irrigation Project Operations Plans dictate Upper Klamath Lake level targets and instream flow needs downstream from Iron Gate dam (see Exhibit B for further detailed descriptions of this process). The overall effects of the Upper Klamath River basin operations and diversions have generally resulted in an increase in winter flows and a decrease in late-spring and early-summer flows in the river just downstream from Iron Gate dam (Balance Hydrologics, 1996; Ayers Associates, 1999).

Some accretion of flow occurs over the 64 miles of river where the Project facilities are located. Natural springs contribute a relatively constant flow to the Klamath River between J.C. Boyle dam and its powerhouse between about river mile (RM) 220 and RM 225. These springs contribute about 225 cfs.

Tributaries to the Klamath River in the Project area between Link River dam and Iron Gate dam are relatively small. The largest include Spencer Creek (approximately 20 to 200 cfs), which flows into J.C. Boyle reservoir; Shovel Creek (10 to 100 cfs), which enters the river just upstream from Copco reservoir; and Fall Creek (30 to 100 cfs) and Jenny Creek (30 to 500 cfs), which flow into Iron Gate reservoir. Spencer, Shovel, and Jenny creeks all have irrigation diversions that remove some water from them.

E3.1.3 Review of Previous Studies on Hydrology and Flow Availability

A report by Balance Hydrologics (1996), prepared on behalf of the Yurok Tribe, discusses the impact of USBR's Klamath Irrigation Project on instream flows below Iron Gate dam. The report attempts to quantify the extent to which the USBR Klamath Irrigation Project has affected seasonal flows in the river. In general, the report describes an increase in winter flows and a decrease in late-spring and summer flows. The report also makes the link between subsurface storage in the upper basin and base flows in the Klamath River, suggesting that consumptive irrigation use may diminish the storage subsurface flows historically provided, and surface flows are correlated to precipitation in the basin over the previous several years. Balance Hydrologics (1996) offers several flow management recommendations, including increasing storage in Upper Klamath Lake, artificially recharging runoff to groundwater, conjunctive use of groundwater in certain areas to augment surface flow irrigation, and improving irrigation efficiencies.

Balance Hydrologics (1996) used USGS gauge data from 1905-1912 at Keno, Oregon, supplemented by several other records from downstream, to estimate a without-Project hydrologic record. Rainfall records were used to quantify long-term wet and dry irrigation periods in the past century. In particular, these include severe drought in the 1840s; wet periods in the 1860s, 1905-1917, and 1951-1984; and dry periods during 1872-1890 and 1918-1950.

Ayres Associates (1999) prepared a report for USFWS to evaluate Klamath River geomorphology and to determine if channel geometry and sediment dynamics are changing, particularly downstream of Iron Gate dam. As part of this evaluation, the report presents additional analyses of the hydrologic data in the basin and examines the analysis and conclusions of Balance Hydrologics (1996), agreeing with many but taking issue with some. Specifically, Ayres Associates (1999) disagrees with the correlation procedure for previous year precipitation and subsequent runoff volume, and also disputes the adjustment used to index the relatively short pre-Klamath Irrigation Project gauge data record to normalize it against average expected flows. Ayres Associates (1999) recalculated the index to show that the data prior to the Klamath Irrigation Project are nearly average, not slightly wet, as Balance Hydrologics (1996) reported. This change implied that flows in the basin were not diminishing over time, as Balance Hydrologics (1996) suggested. Ayres Associates (1999) concurs that seasonal shifts are discernible with respect to peak flows and volumes, and that peak discharges have increased in magnitude and frequency since construction of Iron Gate dam. Ayres Associates (1999) also concurs with the Balance Hydrologics (1996) finding of shifts in seasonal averages, with higher winter flows and lower summer flows.

Hardy and Addley (2001) prepared a detailed study for USFWS to evaluate instream flow requirements downstream of Iron Gate dam. There have been two phases to the study, an initial evaluation of the basin (Phase I), and a more detailed habitat analysis and modeling effort (Phase II). In Phase II, Hardy and Addley (2001) estimated the "natural" hydrology regime prior to the Klamath Irrigation Project ("unimpaired no-project flows") and other flow management scenarios generated through model simulations, including data from KPOPSIM and MODSIM models of the basin. Four different flow scenarios were considered:

- Unimpaired flows without the Klamath Irrigation Project
- USGS-simulated historical operations of the Klamath Irrigation Project
- Klamath Irrigation Project operations with current FERC and USFWS requirements
- Klamath Irrigation Project operations based on the Phase I instream flow requirements[2]

The main thrust of Hardy and Addley's (2001) hydrologic work was to develop suitable year classifications for the Klamath River and establish instream flow targets that would produce acceptable instream flow conditions for anadromous fish life stages. Hardy and Addley's (2001) computation of unimpaired flows was deemed essential for depicting historical flow versus fishery conditions, the relationships of which were used to establish subsequent instream flow target releases from Iron Gate dam. These scenarios were all developed on a monthly or semimonthly time interval.

Hardy and Addley (2001) used several models and the outputs from other existing models to make the analyses. They combined the use of KPSIM (a.k.a. KPOPSIM) and MODSIM to produce model flow output and test impacts to other Klamath Irrigation Project functions. The output from the model MIKE 11 was used to assist in computing unimpaired Klamath River flows. The USGS System Impact Assessment Model (SIAM) model was used to test temperature/flow relationships.

The Hardy and Addley (2001) analysis found that the difference between estimated average annual flow (1.8 million ac-ft) prior to the Klamath Irrigation Project and current conditions (1.5 million ac-ft) represent the consumptive use in the basin by irrigators and other users. Hardy and Addley (2001) estimated some seasonal shifts and changes in peak and trough magnitudes at the monthly time interval, similar to those concluded by the Balance Hydrologics (1996) and Ayres Associates (1999) studies.

E3.1.4 Existing Hydrology and Flow Availability

E3.1.4.1 Hydrologic Data Sources for the Project Area

Four currently operating USGS gauging stations are located on the Klamath River within the Project area: Link River in Klamath Falls (No. 11507500, RM 253.5), near Keno dam

[2] Several flow-statistic methods were evaluated for determining recommended monthly instream flow needs as part of Phase I. In general, these methods, including the Hoppe method, New England flow policy, Northern Great Plains Resource Program method and others, use either flow exceedance relationships or mean annual volume to estimate the necessary flow conditions for fish habitat.

(No. 11509500, RM 232), downstream from J.C. Boyle powerhouse (No. 11510700, RM 220), and downstream from Iron Gate dam just downstream from Bogus Creek (No. 11516530, RM 190). Table E3.1-2 summarizes the drainage area and the data period of record for each of these gauges and three other discontinued USGS flow gauge sites in the Project area: (1) the Klamath River at Spencer Bridge (No. 11510500, RM 226.1); the Klamath River below Fall Creek near Copco (No. 11512500, RM 196), and Fall Creek (No. 11512000, near mouth of creek).

Table E3.1-2. USGS flow gauging data for the Klamath River and Fall Creek in the Project area.

USGS Gauge	Drainage Area (square miles)	Gauge Number	Daily Flow Period of Record	Annual Peak Flow Period of Record
Link River at Klamath Falls	3,810	11507500	10/1/1961-present	5/12/1904-present
Klamath River at Keno	3,920	11509500	6/1/1904-9/30/1913 10/1/1929-present	3/28/1905-9/30/1913 10/1/1929-present
Klamath River at Spencer Bridge near Keno	4,050	11510500	10/1/1913-9/30/1931	4/21/1914-12/15/1930
Klamath River Downstream from J.C. Boyle Powerhouse	4,080	11510700	1/1/1959-9/30/1971 10/1/1974-9/30/1979 10/1/1982-9/30/1987 10/1/1988-present	1/1/1959-9/30/1971 10/1/1974-9/30/1979 10/1/1982-9/30/1987 10/1/1988-present
Klamath River below Fall Creek near Copco	4,370	11512500	10/1/1923-9/30/1961	1/2/1924-12/1/1960
Klamath River Downstream of Iron Gate Dam	4,630	11516530	10/1/1960-present	12/1/1960-present
Fall Creek at Copco	14.6	11512000	4/1/1933-9/30/1959	12/27/1928-7/2/1959

A USGS gauging station (Gauge No. 11512000) operated on Fall Creek from April 1934 to September 1959. A diversion structure at Spring Creek, a tributary to nearby Jenny Creek, has existed since at least the 1950s to carry flow into Fall Creek to increase hydropower production. PacifiCorp estimates that the minimum observed flow in Spring Creek, which is, in fact, spring-fed, is approximately 5 cfs. Therefore, it was assumed that the current and future hydrologic condition in Fall Creek would be appropriately represented by the sum of this diversion and measured flows from the 1934-1959 USGS gauge period of record. This also assumes PacifiCorp will receive an Oregon adjudicated water right for the Spring Creek diversion.

E3.1.4.2 Average Daily Flow Rates

Graphs of average daily flow by month at the four currently operating USGS gauges are provided in the Water Resources FTR, Appendix 5A. Figure E3.1-1 depicts annual hydrographs of average daily flow over the period 1967-2001 for the four USGS gauges. To illustrate flow variation in recent years, Figure E3.1-2 shows the annual hydrographs of average daily flow for the Keno gauge (No. 11509500), together with annual hydrographs for 1991, a critical dry year, and 1998, a wet year.

Graphs of average daily flow by month at the Fall Creek USGS gauge are provided in the Water Resources FTR, Appendix 5B. Figure E3.1-3 shows the 50 percent (median) monthly flow values for Fall Creek for three scenarios. These are (1) period of record only, representing historical Fall Creek conditions without an additional diversion from Spring Creek; (2) 5 cfs diverted, representing the minimum expected Spring Creek diversion flow plus historical conditions; and (3) 16.5 cfs diverted from Spring Creek, the sum of historical conditions and the maximum allowed diversion.[3]

E3.1.4.3 Daily Flow Duration Curves by Month

Daily flow duration curves, by month, at the four key USGS gauges are provided in Appendix 5A of the Water Resources FTR. These curves indicate the percent of days for a particular month that a given flow has been equaled or exceeded. Appendix 5B of the Water Resources FTR provides the 90 percent, 50 percent, and 10 percent exceedance values for Fall Creek flow, corresponding to wet, average, and dry conditions, for the three scenarios described above.

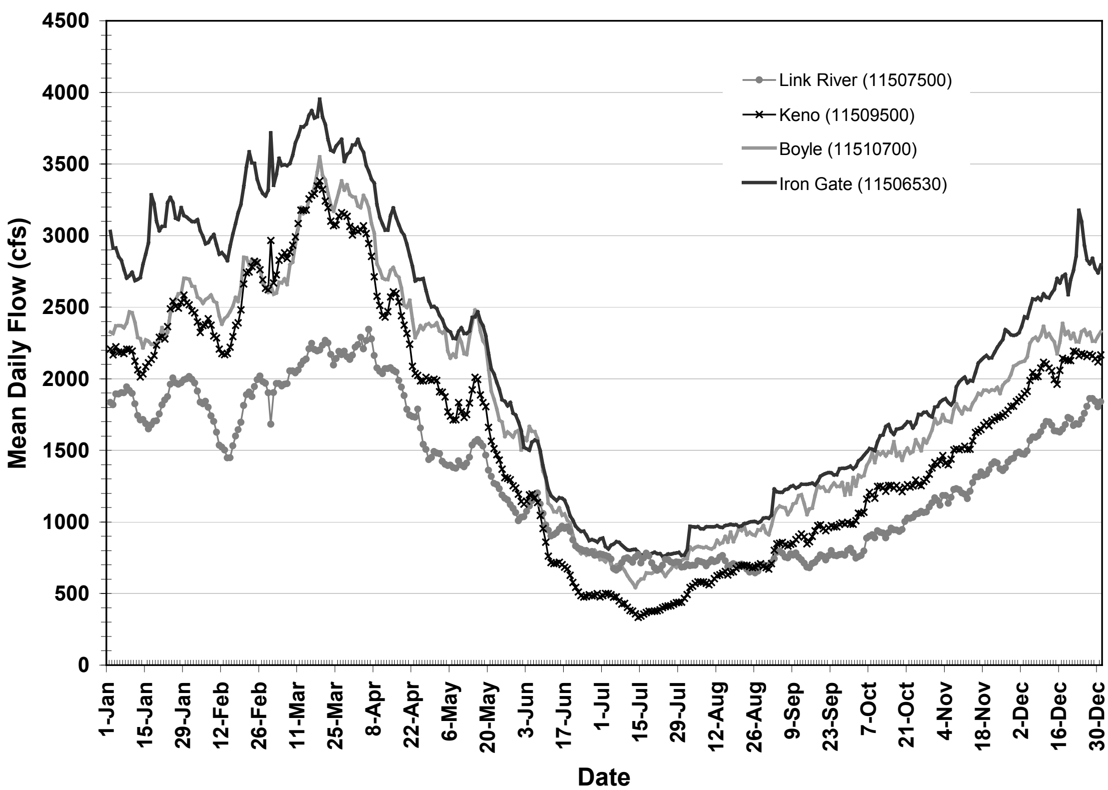


Figure E3.1-1. Annual hydrographs of average daily flows for the period 1967-2001 at four gauging stations on the Klamath River in the Project area.

3 Although it is likely that the range of Spring Creek diversions, 5 to 16.5 cfs, follows a seasonal pattern, with higher flows in later winter and spring and low flows in late summer and autumn, no data were available to confirm this. For that reason, the range of diversions and water year types were overlain to provide a range of flow values and associated exceedances, regardless of time of year.

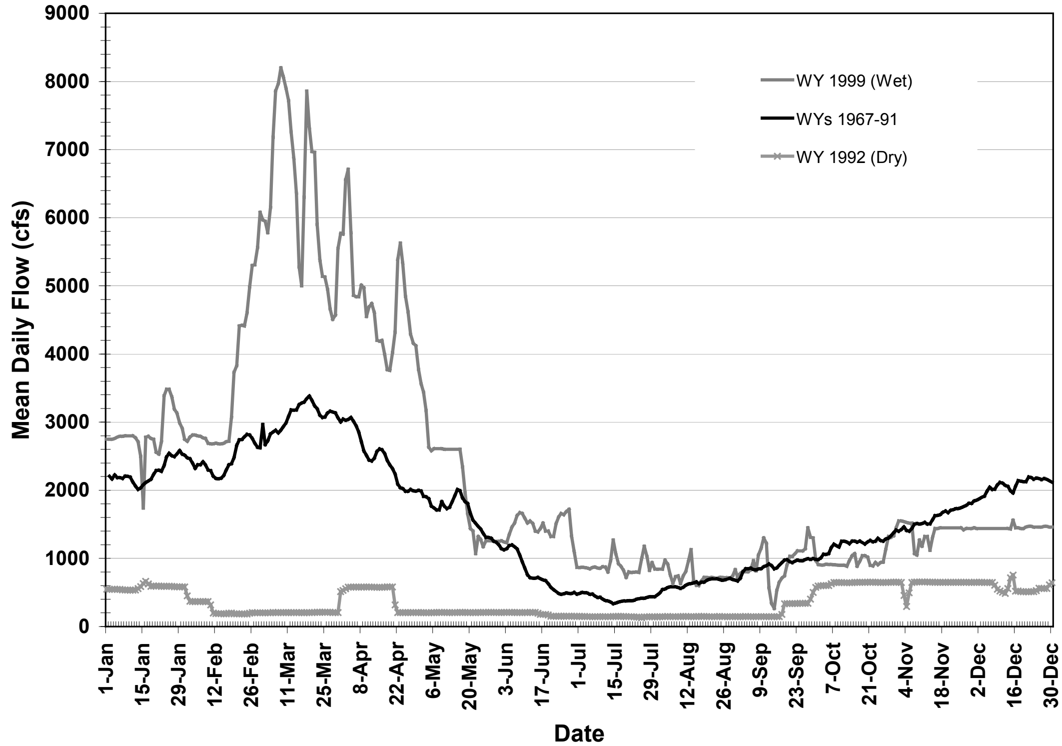


Figure E3.1-2. Annual hydrographs of average daily flows in the Klamath River at Keno (USGS Gauge No. 11509500) for the period 1967-1999, a dry year (1992), and a wet year (1999). The dry and wet water year classifications are based on USBR classification system.

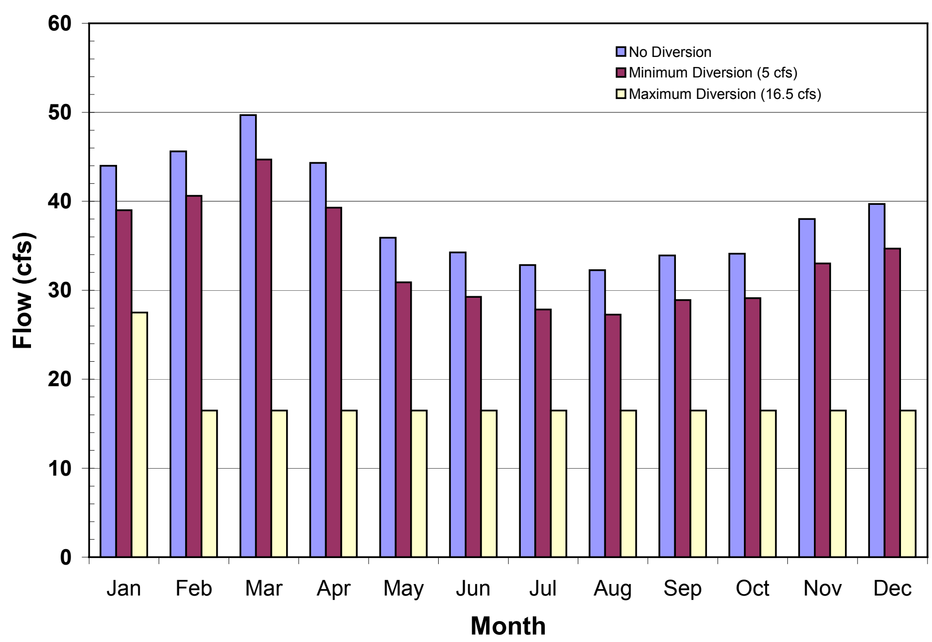


Figure E3.1-3. Estimated monthly median flow values for Fall Creek based on available data from USGS Gauge No. 11512000 for the period of record April 1934 to September 1959. Spring Creek flow may be diverted to Fall Creek throughout the year. For purposes of analysis, the minimum diversion from Spring Creek is estimated to be 5 cfs, and the maximum diversion 16.5 cfs.

E3.1.4.4 Water Year Type and Average Annual Flows in the Klamath River Since 1990

Water year type classifications have been defined by USBR[4] for Klamath Irrigation Project Operations Plans and by Hardy and Addley (2001). These water year types are based on net inflow to Upper Klamath Lake for the April through September period, as defined in Table E3.1-3. Water year types and mean annual discharge since 1990 at USGS gauges in the Project area are listed in Table E3.1-4.

Table E3.1-3. Klamath River water year classifications.

Year Type	Upper Klamath Lake Net Inflow (April-September)
Hardy and Addley (2001) Classification *	
Extremely Wet	Above 785,000 ac-ft
Wet	785,000 to greater than 568,500 ac-ft
Normal	568,500 to greater than 445,000 ac-ft
Dry	445,000 to greater than 270,000 ac-ft
Critically Dry	270,000 ac-ft or less
USBR Classification (per Klamath Irrigation Project 2003 Operations Plan)	
Wet	Above 785,200 ac-ft
Above Average	785,200 to greater than 568,600 ac-ft
Average	568,500 to greater than 458,400 ac-ft
Below Average	458,300 to greater than 286,800 ac-ft
Dry	Less than 286,800 ac-ft

* The Upper Klamath Lake net inflow values assumed for the Hardy and Addley (2001) classification were estimated from Hardy and Addley (2001, Table 19, page 97).

4 Per the Klamath Irrigation Project 2003 Operations Plan (April 10, 2003)

Table E3.1-4. Mean annual discharge (cfs) and water year types since 1990 at USGS gauges in the Project area.

Year	Water Year Type		Annual Mean Discharge (cfs)			
	USBR (2003) System	**Hardy and Addley (2001) System**	**At Link River (USGS Gauge No. 11507500)**	**At Keno (USGS Gauge No. 11509500)**	**Below J.C. Boyle Powerhouse (USGS Gauge No. 11510700)**	**At Iron Gate Dam (USGS Gauge No. 11516530)**
1990	Below average	Dry	815	969	1213	1351
1991	Dry	Critically dry	494	467	698	827
1992	Dry	Critically dry	555	356	578	649
1993	Above average	Wet	1397	1569	1850	2046
1994	Dry	Critically dry	615	482	691	784
1995	Average	Normal	1092	1217	1550	1802
1996	Above average	Wet	1891	2247	2577	2983
1997	Average	Normal	1705	2021	2351	2626
1998	Above average	Wet	1832	2545	2788	3058
1999	Wet	Extremely wet	1762	2283	2592	2881
2000	Average*	Normal*	1377	1487	1782	1968
2001	Below average *	Dry*	911	971	1227	1341

*USBR (2003) and Hardy and Addley (2001) did not define water year types for 2000 and 2001. Water year types are estimated here based on comparison with other years. Year 2000 is most similar to 1993 and 1995, and year 2001 is most similar to 1990.

E3.1.5 Existing Uses of Water in the Project Area

Within the Project area, current uses of water include aquatic and terrestrial wildlife, recreation endeavors (e.g., whitewater rafting and angling), hydroelectric power generation, and irrigation. Existing instream flow releases for protection of instream uses (e.g., fish and wildlife) are described below. Irrigation and hydroelectric uses are described in preceding section E3.1.1. Recreation uses are described in (Recreation Resources) of this Exhibit E.

For water quality management under the federal Clean Water Act, Oregon has designated beneficial uses of the Klamath River between Upper Klamath Lake and the Oregon-California border in Oregon Administrative Rule (OAR) 340-041-0962. California has designated beneficial uses for the Middle Klamath River Hydrologic Area in the Water Quality Control Plan for the North Coast Region, adopted and amended by the North Coast Regional Water Quality Control Board (NCRWQCB, 1994) and approved by the State Water Resources Control Board. These beneficial uses are described in section E3.4.

The following sections describe flow-related Project operations and flow conditions, including minimum instream flow releases, for each of the main river reaches affected by Project facilities.

E3.1.5.1 Link River

Flow-Related Operations and Minimum Instream Flow Releases in Link River

The Link River reach includes the relatively short 1.2-mile reach of the Klamath River from USBR's Link River dam (RM 254.3) to the inlet to Lake Ewauna (upper section of Keno reservoir, about RM 253.1). Link River dam is located at the outlet from Upper Klamath Lake. USBR owns the dam and PacifiCorp operates it, as specified by USBR under the 1956 contract. Link River dam operates principally to maintain Upper Klamath Lake elevations and to provide needed instream flows in the Klamath River downstream of Iron Gate dam. Link River dam also provides control for diversion of flow to USBR's Klamath Irrigation Project and to PacifiCorp's East Side and West Side powerhouses.

The East Side powerhouse is operated continuously with discharge from Upper Klamath Lake. The powerhouse generates with flows provided from Upper Klamath Lake to meet downstream needs, including USBR's Klamath Irrigation Project and ESA flows downstream of Iron Gate dam. The exception to this type of operation is during late July into October when the powerhouse operates in a diurnal fashion, reducing flows through the powerhouse at night to 200 cfs. This operation minimizes potential entrainment of ESA-listed Lost River and shortnose suckers.

The East Side powerhouse has a single vertical Francis turbine with a hydraulic capacity of about 975 cfs. The West Side powerhouse has a single horizontal Francis turbine with a hydraulic capacity of about 250 cfs. The West Side powerhouse is generally operated when additional outflow from Upper Klamath Lake is available. It is usually operated at a fixed discharge (full gate, about 250 cfs) for an extended period.

Under cooperative agreement with the Oregon Department of Fish and Wildlife (ODFW), a minimum flow of at least 90 cfs is currently maintained in Link River between Link River dam and the East Side powerhouse. PacifiCorp currently maintains a minimum flow of 450 cfs in Link River below the East Side powerhouse. Maximum ramping rates are 100 cfs per 30 minutes when flows are 500 to 1,500 cfs, 50 cfs per 30 minutes when flows are 300 to 500 cfs, and 20 cfs per 5 minutes when flows are less than 300 cfs. These rates are stipulated by the 2001 BO on ESA consultation for shortnose and Lost River suckers.

PacifiCorp plans to decommission the East Side and West Side facilities; therefore, the facilities will no longer be operated under a new FERC license. The decommissioning of these facilities is described in Exhibit A.

Flow Conditions in Link River

Upper Klamath Lake's outflow is the dominant flow source to Link River and all downstream reaches through the Project area. Upper Klamath Lake provides a very large active storage volume that can be controlled by Link River dam. Operation of Link River dam using the lake's large active storage volume largely dictates the long-term (annual, seasonal) hydrograph and magnitude of high flow events that pass through the system. This operation is also the predominant means of providing instream flows downstream of Iron Gate dam. Characteristics of Upper Klamath Lake and its storage capacity are listed in Table E3.1-5.

Table E3.1-5. Upper Klamath Lake characteristics.

Surface area (acres)	77,593
Maximum/mean depth (feet)	50/7.8
Normal full lake elevation (feet msl)	4,143.30
Normal minimum lake elevation (feet msl)	4,136.00
Normal annual operating fluctuation (feet)	7.3
Normal active storage capacity (ac-ft)	486,800
Active storage retention time (days)	
At 500 cfs	490
At 1,100 cfs (≈ mean flow)	223
At 6,000 cfs (extreme event)	41

Recent annual trends in Upper Klamath Lake elevations and flows in Link River are depicted in Figure E3.1-4. In recent years, Upper Klamath Lake has been operated mostly between lake elevations of about 4,139 and 4,143 feet mean sea level (msl) in response to biological needs of ESA-listed fish species. In prior years, Upper Klamath Lake was operated within a wider range in lake elevations of between approximately 4,136 and 4,143 feet msl. Even in recent years (when Upper Klamath Lake has been operated between a narrower range of lake elevations in response to biological needs of ESA-listed fish species), the lake makes up 93 percent of the total available active storage upstream of Iron Gate dam. The Keno, J.C. Boyle, Copco, and Iron Gate reservoirs combined account for the remaining 7 percent of the total available active storage upstream of Iron Gate dam.

Diversion of flows at Link dam for operation of the East Side and West Side facilities results in a reduction in flows in the bypass reach of Link River, as shown in Figure E3.1.4. Flows can be reduced by up to 975 cfs in the bypass reach between Link dam and East Side powerhouse, and up to 250 cfs between East Side and West Side powerhouses. However, the decommissioning of the East Side and West Side facilities will end such flow reductions in Link River in the future.

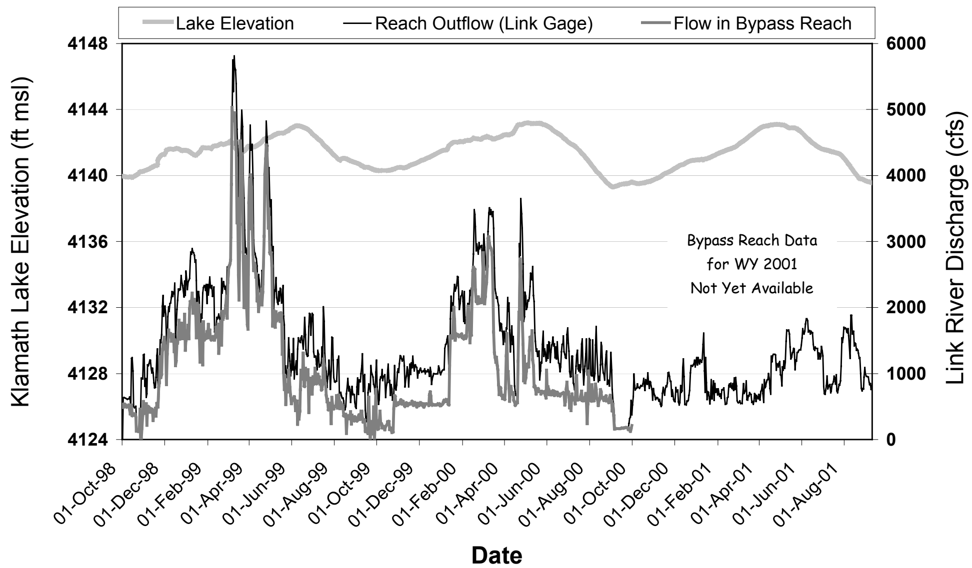


Figure E3.1-4. Daily average Upper Klamath Lake elevation and estimated discharge in Link River for Water Years 1999-2001.

E3.1.5.2 Keno

Flow-Related Operations and Minimum Instream Flow Releases at the Keno Development

Lake Ewauna/Keno reservoir is formed by Keno dam on the Klamath River at approximately RM 233. The impoundment, formed in 1967, is approximately 20 miles in length. Lake Ewauna proper is a wide, relatively shallow body of water extending from about RM 251 to 253, while Keno reservoir is a narrower reach between RM 233 and 251.

Keno is a re-regulating facility with no generating capability. It is operated as a diversion dam to control Keno reservoir for agricultural diversions by USBR's Klamath Irrigation Project, other local irrigators, and ODFW's wildlife refuge. PacifiCorp has a cooperative agreement with ODFW for a minimum instream flow release of 200 cfs from Keno dam. There is currently no required FERC ramp rate below Keno dam. However, PacifiCorp manages flow ramp rates to no more than 500 cfs per hour or 9 inches per hour.

Because the Keno facility is operated to maintain Keno reservoir at an approximately constant elevation, reservoir levels rarely fluctuate more than 0.5 foot seasonally (Figure E3.1-5). The steady reservoir elevation allows USBR to manage its irrigation water through its diversion channels from Keno reservoir, and enables PacifiCorp to more effectively plan downstream load following operations at the J.C. Boyle powerhouse. The reservoir may be drawn down a few feet for 1 to 2 days each year (usually during March-April) to allow irrigators to access pumps and canals for maintenance. Because of its relatively small active storage, Keno reservoir has a modest effect on the general shape and trend of annual hydrographs (Figure E3.1-5). Characteristics of Lake Ewauna/Keno reservoir and its storage capacity are listed in Table E3.1-6.

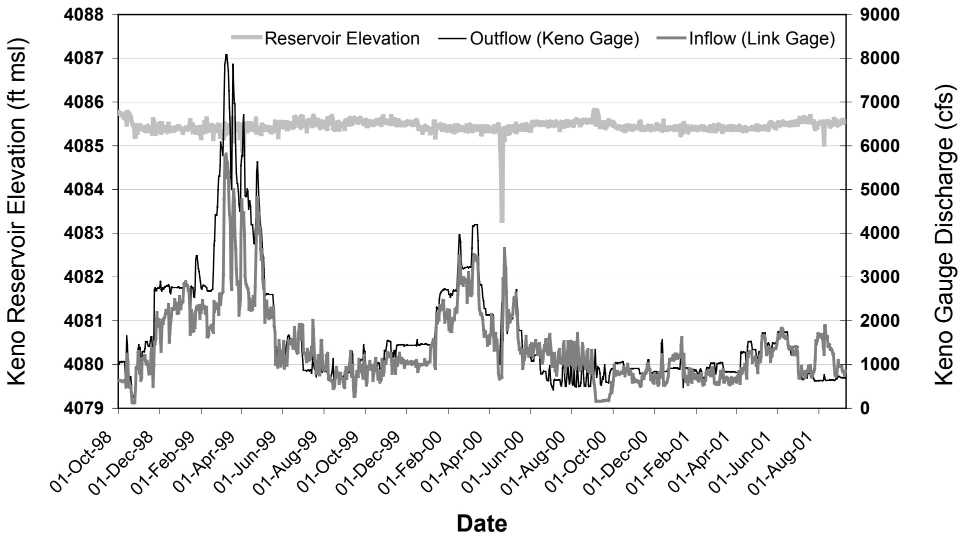


Figure E3.1-5. Daily average Keno reservoir elevation and estimated reservoir inflow and outflow for Water Years 1999-2001.

Table E3.1-6. Lake Ewauna/Keno reservoir physical and operational characteristics.

Impoundment length (miles)	20.1	Normal full pool elevation (feet msl)	4.086
Impoundment length (RM)	233-253.1	Normal minimum pool elevation (feet msl)	4,085
Surface area (acres)	2,475	Normal annual operating fluctuation (feet)	1.0
Maximum/mean depth (feet)	20/7.5	Average daily operating fluctuation (feet)	0.5
Total storage capacity (ac-ft)	18,500	Normal active storage capacity (ac-ft)	2,475 (est.)
Total retention time (days)		Active storage retention time (days)	
At 710 cfs	13	At 710 cfs	1.7
At 1,600 cfs (≈ mean flow)	6	At 1,600 cfs (≈ mean flow)	0.8
At 10,000 cfs (extreme event)	1	At 10,000 cfs (extreme event)	0.1

Inflows within the Lake Ewauna/Keno reservoir reach include releases from Upper Klamath Lake, municipal wastewater discharges, industrial discharges, and agricultural return flow, as well as natural inflow from adjacent areas (Figure E3.1-6, Table 3.1-7). Agricultural returns consist primarily of two point sources: the Lost River diversion canal (RM 249.7) and the Klamath Straits Drain (RM 240.2). Principal diversions include the Lost River diversion canal, North canal, and ADY canal. The Lost River diversion canal can discharge water to the Klamath River as well. Link River inflow makes up just under 80 percent of the total inflow, and agricultural returns account for about 20 percent. Municipal and industrial inflows are about 1 percent. Inflow quantities may vary widely on a day-to-day or week-to-week basis.

The Keno facility is included in PacifiCorp's current FERC license. However, PacifiCorp will not seek to include the Keno facility in the new FERC license for the Project. Therefore, Keno will no longer be operated to provide water storage or flows for Project hydropower generation.

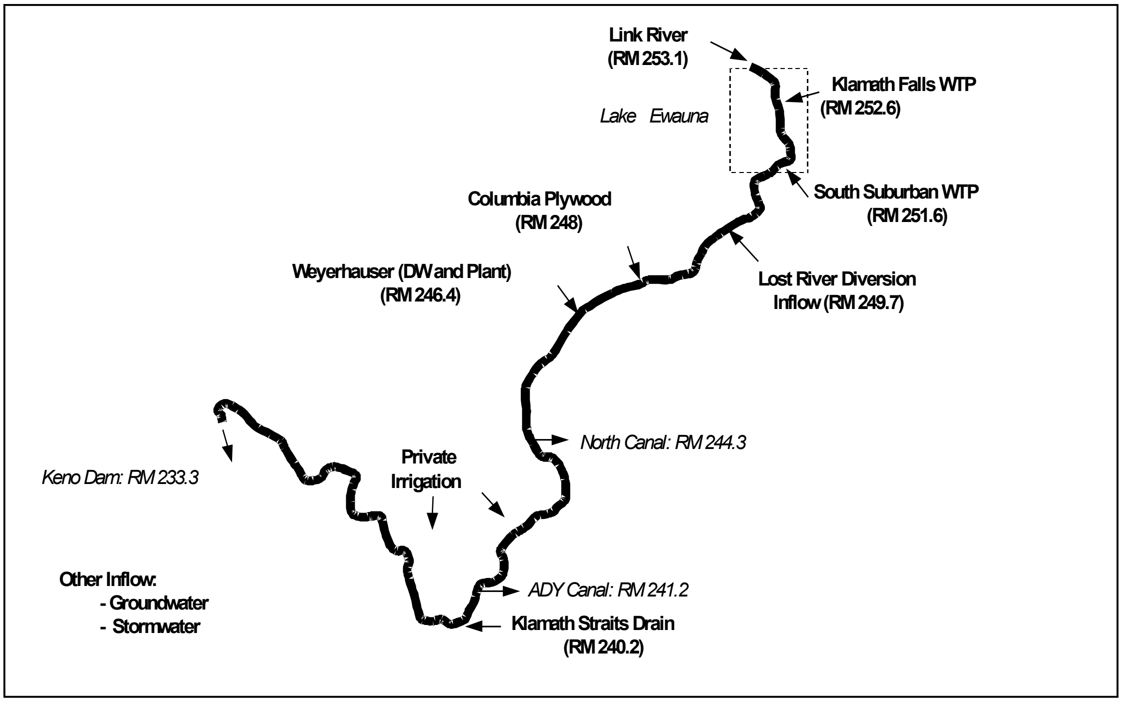


Figure E3.1-6. Lake Ewauna/Keno reservoir inflow locations.

Table E3.1-7. Lake Ewauna/Keno reservoir inflow locations and quantities.

Inflows	RM	Representative Flow*	% of Total*
Link River	253.1	800	77.8
Klamath Falls Water Treatment Plant	252.6	4.5	0.4
South Suburban Water Treatment Plant	251.6	2.2	0.2
Lost River Diversion Canal	249.7	100	9.7
Columbia Plywood	248	n/a	-
Weyerhauser (Domestic and Plant)	246.4	2.0	0.2
Klamath Straits Drain	240.2	120	11.7
Private Irrigation	-	NA	-
Groundwater	-	NA	-
Stormwater	-	NA	-
Total		1,028.7	100

Source: Values adapted from Oregon Department of Environmental Quality (ODEQ), 1995.

*Based on available flow data, i.e., not including private irrigation return, groundwater, and stormwater.

Flow Conditions in the Keno River Reach

The Keno River reach includes the 5-mile river reach of the Klamath River from Keno dam (RM 233) to the upper end of J.C. Boyle reservoir (about RM 228). The flow conditions in the Keno River reach consist predominantly of releases from Keno dam, as described above and shown in Figure E3.1-5. Because of its relatively small active storage, Keno reservoir has a modest effect on the general shape and trend of the hydrograph of reservoir inflows. Therefore, Keno dam is essentially operated as a run-of-river facility so that inflows to Keno reservoir are passed through Keno dam with little alteration. No significant tributaries enter the reach.

Although Keno reservoir levels are relatively constant (rarely fluctuating more than 0.5 foot) and Keno dam is essentially operated as a run-of-river facility, short-term fluctuations in flow are evident at times (Figure 3.1-7). Such fluctuations are mainly due to the effects of diversions and return flows from the Klamath Irrigation Project.

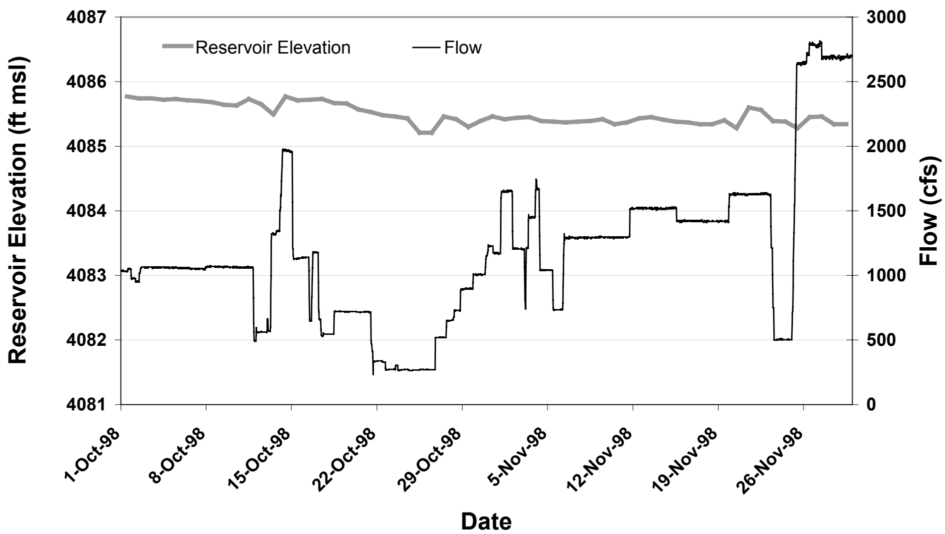


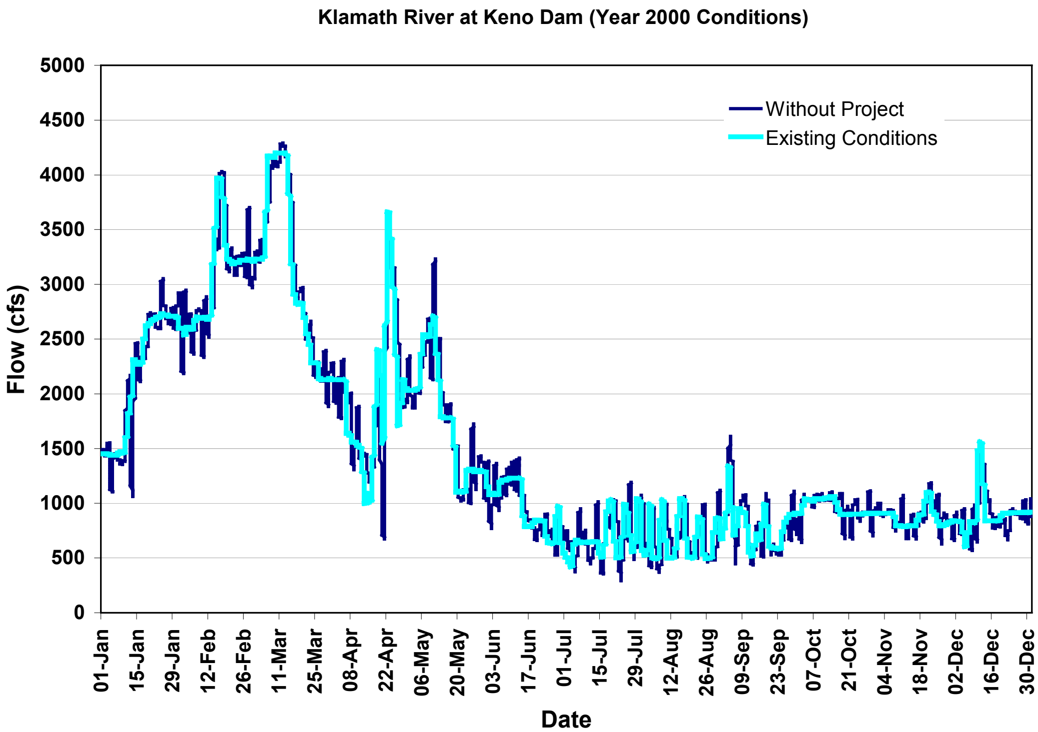
Figure E3.1-7. Keno reservoir elevation and hourly discharge below Keno dam during October and November 1998.

Modeled Project Effects

Graphs of RMA-2 model[5] output of hourly flow (cfs) in the Keno reach of the Klamath River (at RM 232.9) are shown for existing conditions, steady flow, and the two hypothetical without-Project scenarios (WOP and WOP II) in the Water Resources FTR, Appendix 5C. Of the four scenarios, the comparison between existing conditions and WOP scenarios shown in those figures best illustrates the effects on flow caused by Project facilities and operations in the Keno reach.[6] Graphs comparing model output of flow for existing conditions and WOP scenarios are shown in Figure E3.1-8 for 2000 and 2001 conditions.

[5] RMA-2 is a finite element hydrodynamic model capable of modeling highly dynamic flow regimes at short space and time steps. The output from this model includes velocity, depth, a representative surface, and bed areas.

[6] The comparison of existing conditions and WOP scenarios is used in this analysis as the best comparison for isolating Project effects on flow from both Project facilities (i.e., structures) and their operations. The steady flow scenario is intended to help assess the effects due to Project operations only. The WOP II scenario was requested by stakeholders. Stakeholders have suggested that, in a real without-Project situation, flow fluctuations at Keno from USBR's Klamath Irrigation Project operations would be discontinued in favor of smoother flow changes. Such smoother flow changes are assumed in the WOP II scenario. However, because the WOP II scenario required significant changes to the model's flow boundary conditions, a comparison of existing conditions and WOP II scenarios includes substantial differences that are not attributable to Project effects. The comparison of existing conditions and WOP II scenarios is thus less useful for isolating Project effects on flow.



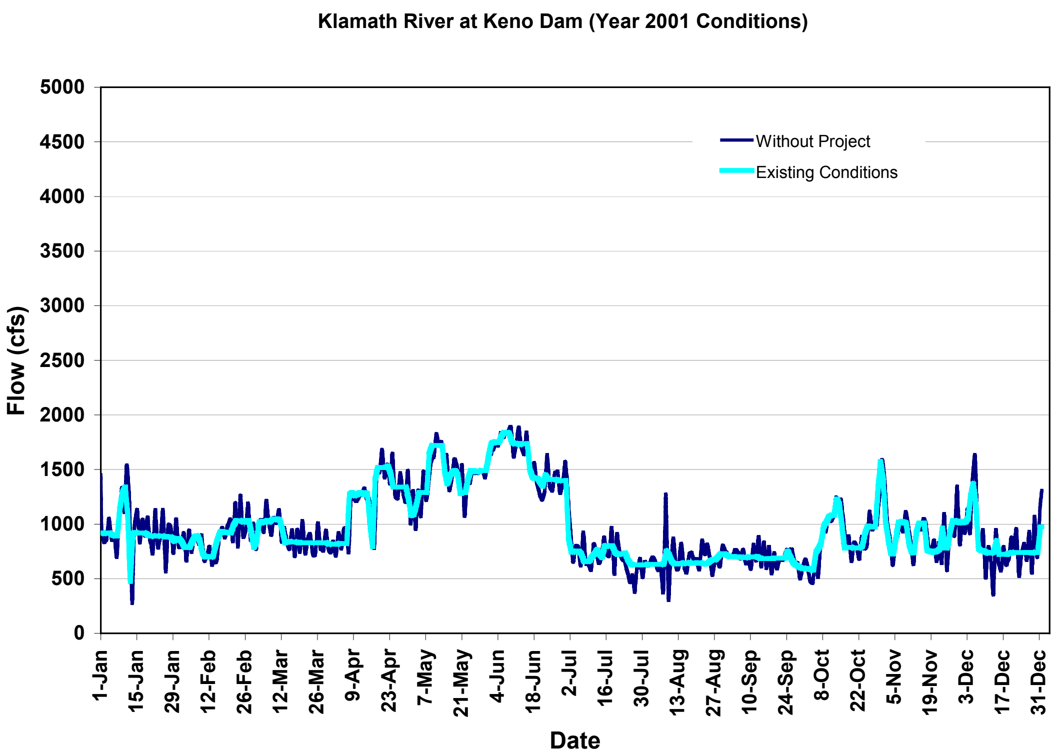


Figure E3.1-8. RMA-2 model output of hourly flow for 2000 and 2001 in the Keno reach of the Klamath River (at Keno dam) for existing conditions and a hypothetical without-Project scenario (WOP). The model output is displayed as an annual time series for 2000 in the top plot and 2001 in the bottom plot.

In general, Project facilities and operations have a modest effect on the magnitude, timing, and duration of flow in the Keno reach compared to WOP conditions. Because the water level in the Keno reservoir is generally maintained at a constant level, the reservoir operates in a run-of-river mode whereby the reservoir's outflow mimics its inflow.

Figure E3.1-8 reveals some moderation in short-term WOP flow fluctuations under existing operation conditions. The short-term WOP fluctuations are primarily an artifact of various flow inputs to and outputs from Keno reservoir, mainly from Klamath Irrigation Project operations. This moderation in short-term WOP flow fluctuations indicates that Keno reservoir's active storage, although rather limited,[7] provides some dampening of these flow fluctuations.

E3.1.5.3 J.C. Boyle

Flow-Related Operations at the J.C. Boyle Development

The J.C. Boyle Development consists of the J.C. Boyle reservoir, dam, and powerhouse. The J.C. Boyle reservoir includes the portion of the mainstem Klamath River from J.C. Boyle dam (RM 224.7) to the upper end of the reservoir (RM 228) near the mouth of Spencer Creek. J.C. Boyle reservoir is the smallest of PacifiCorp's three mainstem reservoirs and has relatively short flow retention rates (about 1 day at the average flow of 1,600 cfs, and about 2.5 days at 700 cfs). Because of its relatively small active storage, J.C. Boyle reservoir has a modest effect on the general shape and peak magnitude of annual hydrographs (Figure E3.1-9). Characteristics of J.C. Boyle reservoir and its storage capacity are listed in Table E3.1-8.

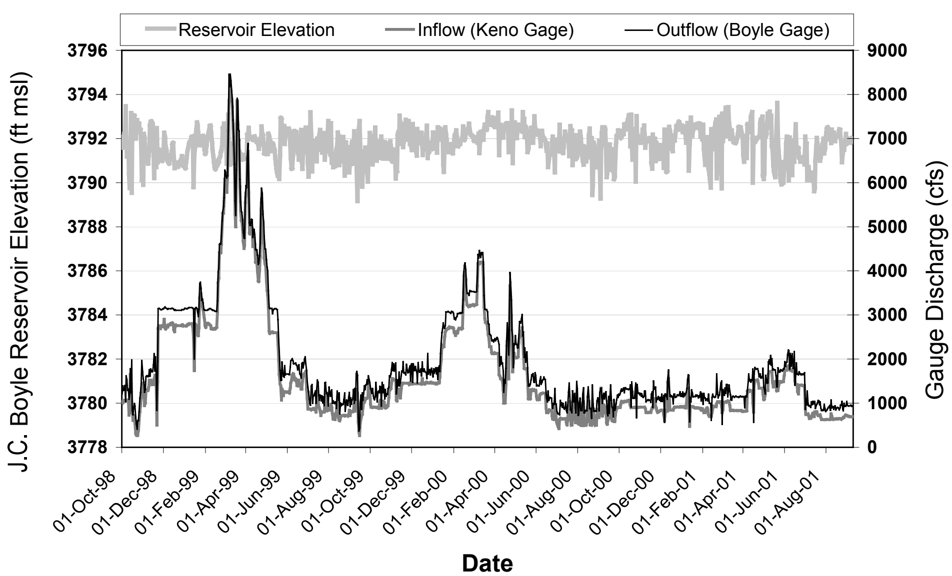


Figure E3.1-9. Daily average J.C. Boyle reservoir elevation and estimated reservoir inflow and outflow for Water Years 1999-2001.

7 Keno reservoir's active storage is only about 2,475 ac-ft. Of this total, only about 1,250 ac-ft are typically used on a daily basis—equivalent to about a half-day's storage at a flow of 1,000 cfs.

Table E3.1-8. J.C. Boyle reservoir physical and operational characteristics.

Impoundment length (miles)	3.3	Normal full pool elevation (feet msl)	3,793.5
Impoundment length (RM)	224.7-228	Normal minimum pool elevation (feet msl)	3,788.0
Surface area (acres)	420	Normal annual operating fluctuation (feet)	5.5
Maximum / mean depth (feet)	40/8.3	Average daily operating fluctuation (feet)	2.0
Total storage capacity (ac-ft)	3,495	Normal active storage capacity (ac-ft)	1,724
Total retention time (days)		Active storage retention time (days)	
At 710 cfs	2.5	At 710 cfs	1.2
At 1,600 cfs (≈ mean flow)	1.1	At 1,600 cfs (≈ mean flow)	0.5
At 10,000 cfs (extreme event)	0.2	At 10,000 cfs (extreme event)	0.1

The J.C. Boyle powerhouse is located 4.3 miles downriver from the dam at RM 220.4. The powerhouse is generally operated in a peaking mode when river flows are less than about 2,850 cfs (i.e., hydraulic turbine capacity). This generally occurs throughout the year outside the spring months when flows are highest (Figure E3.1-10). The occurrence of peaking versus constant generation or spill during the year varies by water year type (Table E3.1-9). In particularly dry years, peaking can occur nearly year-round.

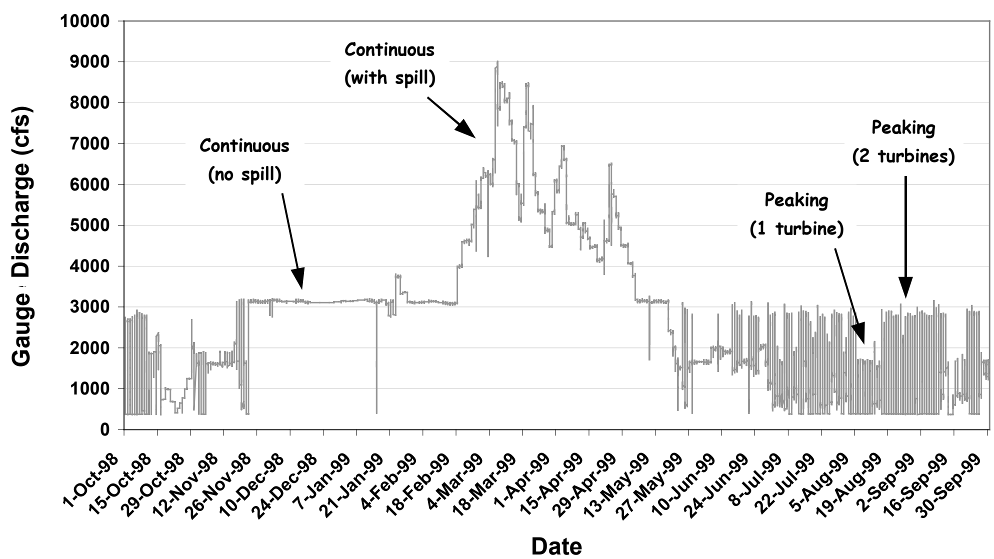


Figure E3.1-10. Hourly discharge below the J.C. Boyle powerhouse during Water Year 1999.

Table E3.1-9. Number of days of J.C. Boyle Development peaking and spill operations by year based on recent water years of hourly data.

Year	Water Year Type (USBR)	No. of Days 1-Unit Peaking	No. of Days 2-Unit Peaking	No. of Days Constant Generation	No. of Days with Spill
1991	Dry	283	35	47	16
1992	Dry	233	2	130	0
1997	Average	93	161	111	86
1998	Above average	12	188	165	122
1999	Wet	21	94	259	101
2000	Average	70	196	99	43
2001	Below average	165	151	49	0

Daily peaking typically occurs when river flows are less than the maximum powerhouse hydraulic capacity of 2,850 cfs, although the typical maximum powerhouse flow is 2,500 cfs to maximize turbine efficiency. During peaking, the reservoir is drawn down to augment inflows and allow operation of the turbine-generators at high loads near peak efficiency (Figure E3.1-11). During off-peak hours, inflows to J.C. Boyle reservoir are stored in the reservoir at night when generation is not occurring, raising the reservoir water level. Daily inflows can be fully regulated with a 2-foot reservoir water level fluctuation. On an annual basis, reservoir levels rarely fluctuate more than about 2.5 feet.

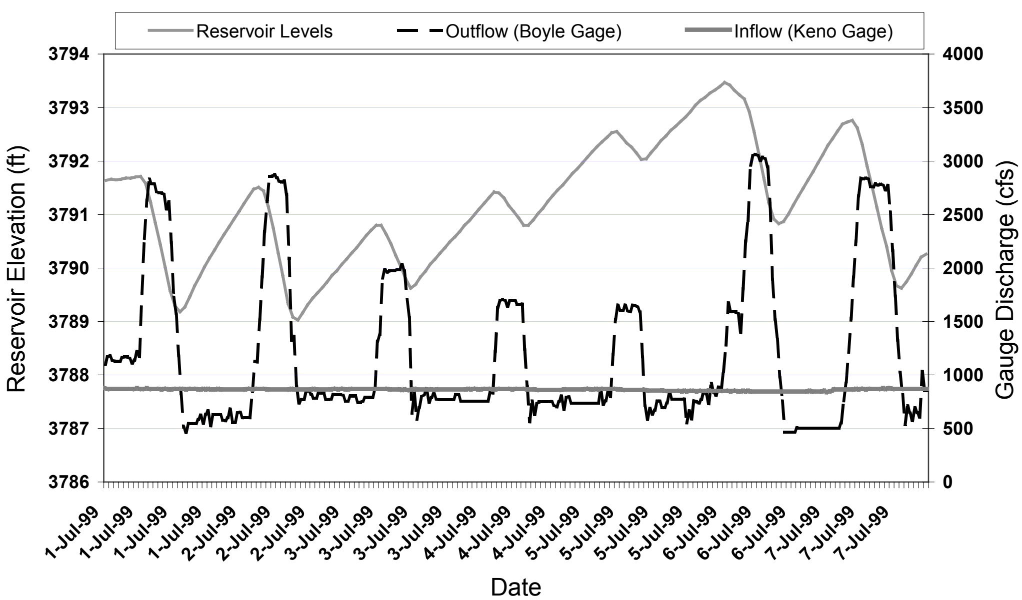


Figure E3.1-11. Hourly J.C. Boyle reservoir elevation and estimated reservoir inflow and outflow during July 1-7, 1999.

Flow Conditions and Minimum Instream Flows in the J.C. Boyle Bypass and Peaking Reaches

The reach of the Klamath River between the dam and powerhouse is referred to as the J.C. Boyle bypass reach (RM 220.4 to 224.7). The 16.4-mile river reach of the Klamath River from the

J.C. Boyle powerhouse (RM 220.4) to the upper end of Copco reservoir (at about RM 204) is referred to as the J.C. Boyle peaking reach (RM 220.4 to 224.7).

No major tributaries occur in the J.C. Boyle bypass reach. The existing FERC-stipulated minimum flow requirement is 100 cfs at the dam. Natural springs contribute an estimated 200 to 270 cfs (mean of 225 cfs) to the river channel in the bypass reach. PacifiCorp based these estimates on measurements at the USGS gauge (No. 11510700) just downstream of the J.C. Boyle powerhouse during occasions when the powerhouse was not operating, subtracting 100 cfs from the gauge readings to account for minimum instream flow releases from J.C. Boyle dam.

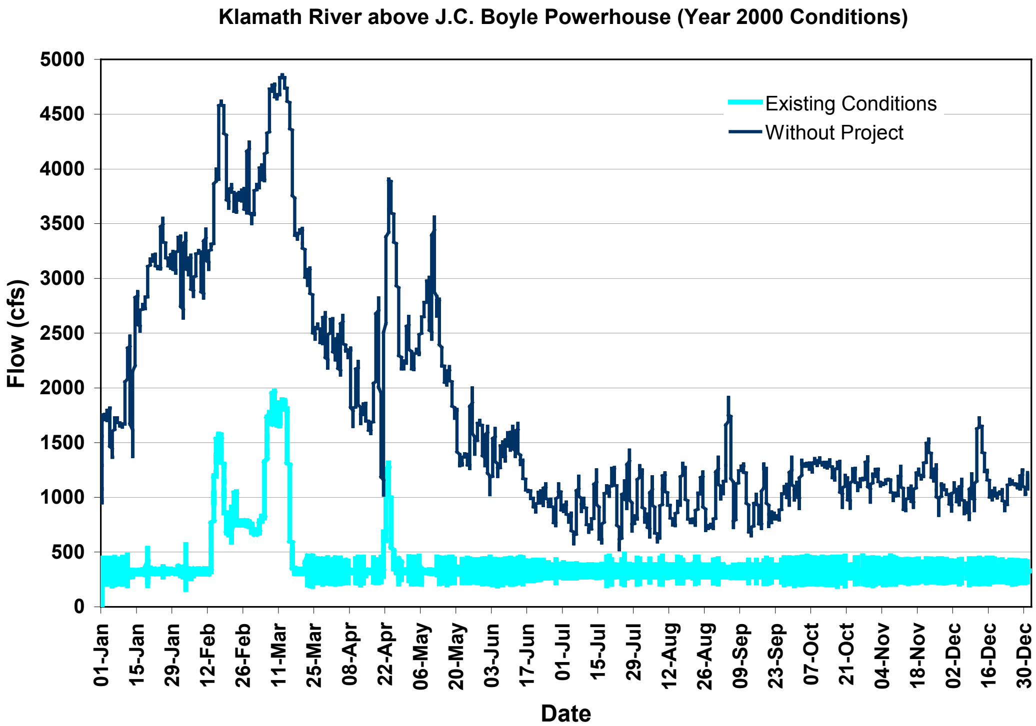
Several small tributaries occur in the J.C. Boyle peaking reach, but they contribute only a minor amount to the overall flow of the Klamath River. Shovel Creek, a key tributary for trout spawning and rearing, enters the river at about RM 206.4. The minimum flow in the peaking reach is about 320 cfs, consisting of the existing FERC-stipulated minimum flow requirement of 100 cfs in the upstream bypass reach below the dam and spring water accretion. The existing FERC-stipulated maximum flow ramping rate is 9 inches per hour as measured at the USGS gauge (No. 11510700) just downstream of the J.C. Boyle powerhouse.

Modeled Project Effects

Graphs of RMA-2 model output of hourly flow (cfs) in the J.C. Boyle bypass and peaking reaches of the Klamath River are shown for existing conditions, steady flow, and the two without-Project scenarios (WOP and WOP II) in the Water Resources FTR, Appendix 5C. Of the four scenarios, the comparison between existing conditions and WOP scenarios shown in those figures best illustrates the effects on flow caused by Project facilities and operations in the J.C. Boyle bypass and peaking reaches. Graphs comparing model output of flow for existing conditions and WOP scenarios in the J.C. Boyle bypass reach just above the J.C. Boyle powerhouse (RM 221) are shown in Figure E3.1-12 for 2000 and 2001 conditions. Graphs comparing model output of flow for existing conditions and WOP scenarios in the J.C. Boyle peaking reach at Stateline (RM 209.2) are shown in Figure E3.1-13 for 2000 and 2001 conditions.

Figure E3.1-12 illustrates the reduction in flows in the J.C. Boyle bypass reach resulting from diversion of flow at J.C. Boyle dam to the power conduit and powerhouse. Compared to WOP conditions, the magnitude of this diversion varies from about 300 cfs to 2,850 cfs (the powerhouse hydraulic capacity). During the two modeled years (2000 and 2001), diversion of flow occurred 100 percent of the time. During 2000, spill from J.C. Boyle dam occurred between mid-February and mid-March, resulting in a flow of up to about 2,000 cfs in the lower end of the bypass reach. At all other times in 2000 and throughout 2001, a constant minimum flow occurred in the bypass reach, resulting in a flow of about 325 cfs in the lower end of the bypass reach (comprising an instream flow release of 100 cfs at the dam and about 225 cfs of spring flow accretion).[8]

[8] Note that the minimum flows depicted for existing conditions in Figures E3-12 and E3-13 show a rather consistent "oscillation" between about 250 and 500 cfs. This is due to a temporary backwater effect in the very lower end of the J.C. Boyle bypass reach during hydropeaking generation startup at the J.C. Boyle powerhouse detected by the RMA-2 hydrodynamic model.



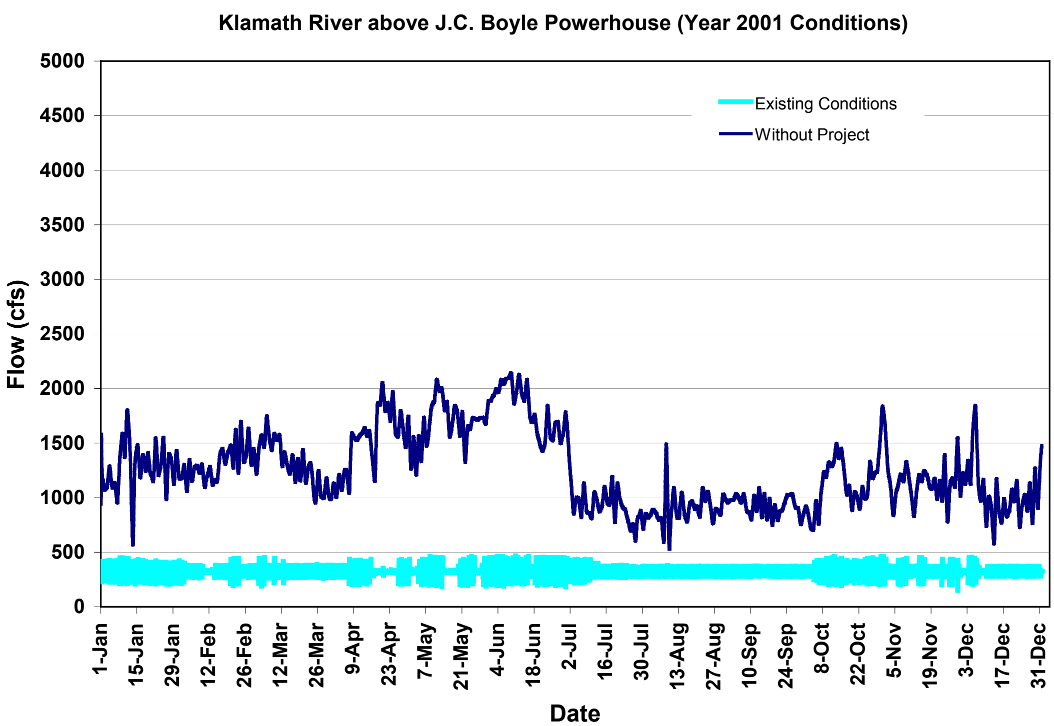
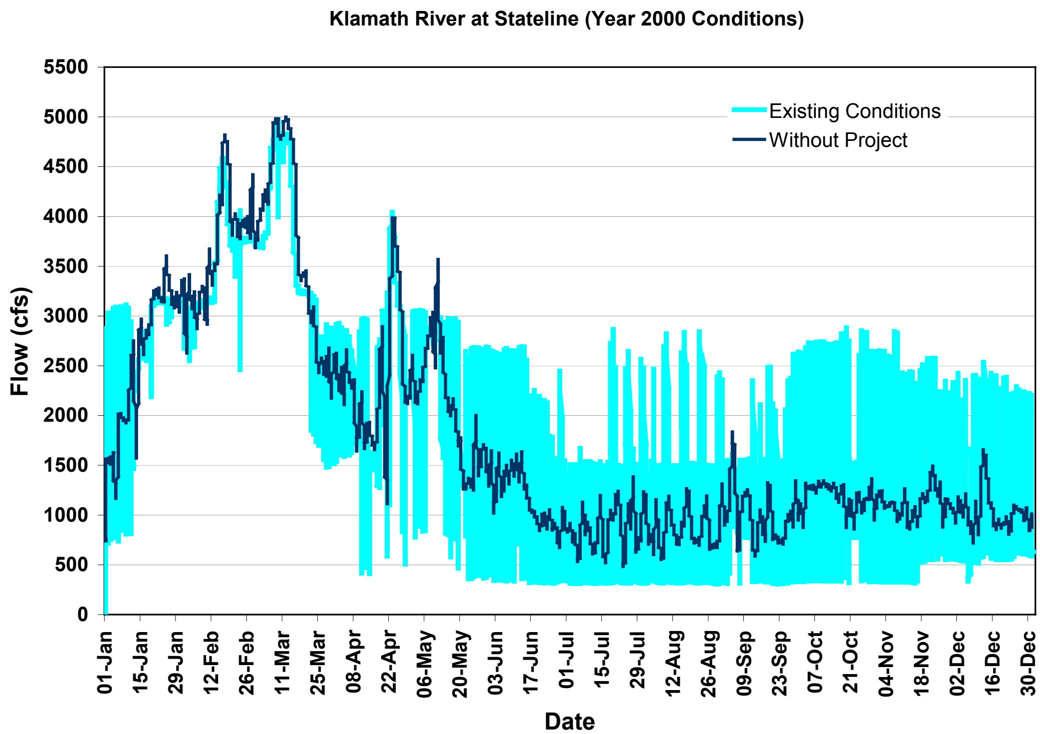


Figure E3.1-12. RMA-2 model output of hourly flow for 2000 and 2001 in the Klamath River above the J.C. Boyle powerhouse (downstream end of the bypass reach) for existing conditions and a hypothetical without-Project scenario (WOP). The model output is displayed as an annual time series for 2000 in the top plot and for 2001 in the bottom plot.



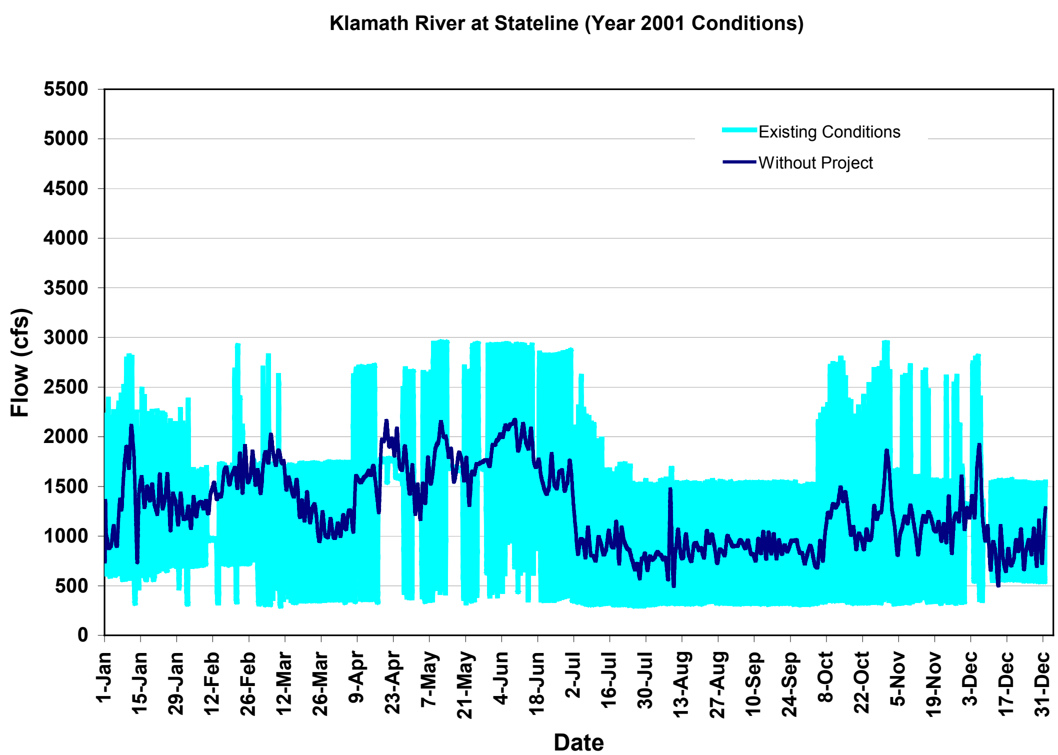


Figure E3.1-13. RMA-2 model output of hourly flow for 2000 and 2001 in the Klamath River at Stateline for existing conditions and a hypothetical without-Project scenario (WOP). The model output is displayed as an annual time series for 2000 in the top plot and for 2001 in the bottom plot.

E3.1.5.4 Copco

Flow-Related Operations at the Copco Developments

The Copco Developments consist of the Copco reservoir, Copco No. 1 dam and powerhouse, the smaller Copco No. 2 diversion pool and dam, and the Copco No. 2 powerhouse. The Copco No. 1 reservoir includes the portion of the mainstem Klamath River from Copco No. 1 dam (RM 198.6) to the upper end of the Copco No. 1 reservoir at about RM 204. Copco No. 1 reservoir typically fluctuates about 6.5 feet annually between normal minimum and full pool elevations (Figure E3.1-14). Because of relatively small active storage, Copco No. 1 reservoir has a modest effect on the general shape and the peak of the annual hydrograph (Figure E3.1-14). Characteristics of Copco reservoir and its storage capacity are listed in Table E3.1-10.

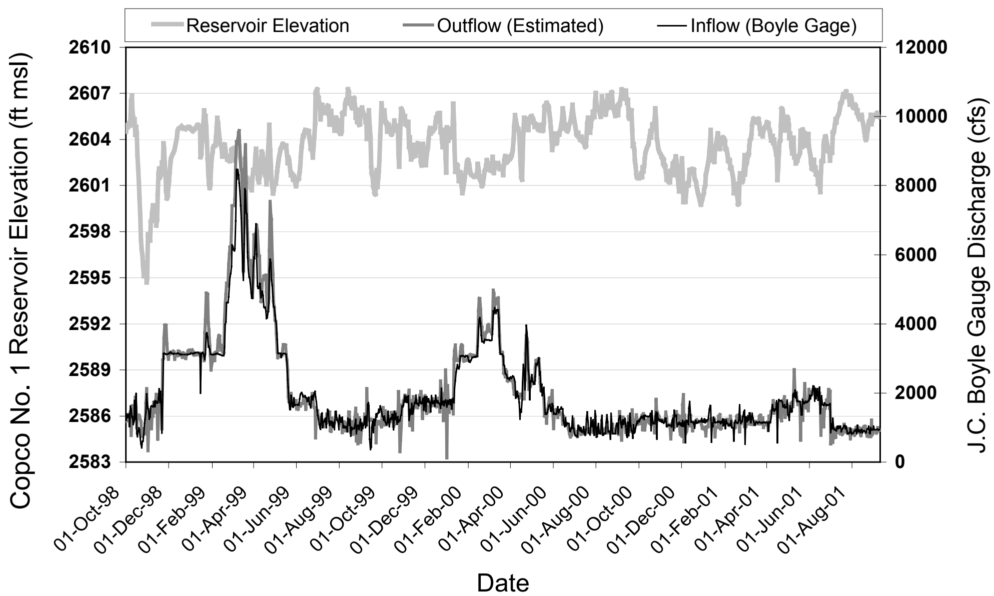


Figure E3.1-14. Daily average Copco No. 1 reservoir elevation and estimated inflow and outflow discharge for Water Years 1999-2001.

Table E3.1-10. Copco No. 1 reservoir physical and operational characteristics.

Impoundment length (miles)	5.4	Normal full pool elevation (feet msl)	2,607.5
Impoundment length (RM)	198.6-204	Normal minimum pool elevation (feet msl)	2,601.0
Surface area (acres)	1,000	Normal annual operating fluctuation (feet)	6.5
Maximum / mean depth (feet)	108 / 47	Average daily operating fluctuation (feet)	0.5
Total storage capacity (ac-ft)	46,867	Normal active storage capacity (ac-ft)	6,235
Total retention time (days)		Active storage retention time (days)	
At 710 cfs	32	At 710 cfs	4.3
At 1,600 cfs (≈ mean flow)	12	At 1,600 cfs (≈ mean flow)	1.6
At 10,000 cfs (extreme event)	2	At 10,000 cfs (extreme event)	0.3

The Copco No. 1 powerhouse is located at the base of Copco No. 1 dam. The powerhouse is generally operated in a peaking mode when river flows are less than about 3,200 cfs (i.e., hydraulic turbine capacity). A more constant generation mode with spill generally occurs during the spring months when river flows exceed about 3,200 cfs (Figures E3.1-14 and E3.1-15). The occurrence of peaking versus constant generation or spill during the year depends on water year type (Table E3.1-11). In dry years, peaking can occur nearly year-round.

Daily peaking is accomplished by using the storage available in Copco No. 1 reservoir. Off-peak inflows are stored in the reservoir, raising the reservoir water level. During peaking, the reservoir is drawn down to augment inflows and allow operation of the turbine-generators at high loads near peak efficiency (Figure 3.1-16). Peaking operation typically results in a 0.5-foot daily fluctuation in reservoir level. On an annual basis, reservoir levels rarely fluctuate more than about 6.5 feet. One or both of the turbine-generators are typically started in the morning to early afternoon and ramped up to best efficiency or full load output. The unit or units are maintained at near-constant load, ramped back down later in the day, and shut off at night (Figure E3.1-16).

Copco No. 2 powerhouse operation follows that of Copco No. 1. When river flows are less than about 3,200 cfs, flows in the bypass reach are about 5 to 10 cfs just below Copco No. 2 dam. Copco No. 1 and No. 2 dams spill additional flow to the bypass reach when river flows are greater than about 3,200 cfs. The discharge from Copco No. 2 powerhouse goes directly into the head end of Iron Gate reservoir.

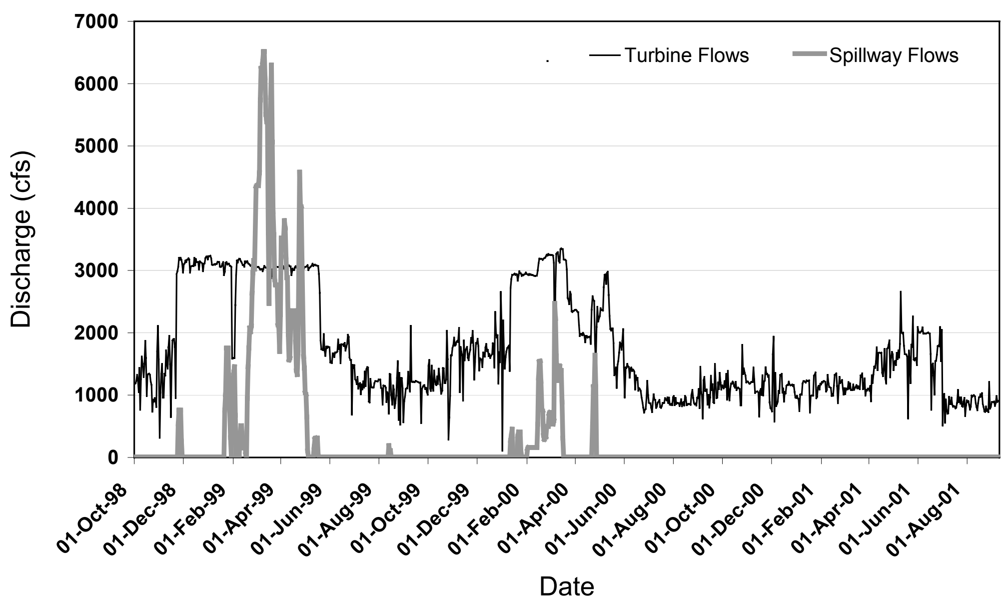


Figure E3.1-15. Daily average spillway and turbine discharges from the Copco No. 1 dam and powerhouse for Water Years 1999-2001.

Table E3.1-11. Number of days of Copco development peaking and spill operations by year.

Year	Water Year Type (USBR)	No. of Days 1-Unit Peaking	No. of Days 2-Unit Peaking	No. of Days Constant Generation	No. of Days with Spill
1991	Dry	**NA**	**NA**	**NA**	7
1992	Dry	**NA**	**NA**	**NA**	0
1997	Average	245	89	31	106
1998	Above average	95	224	46	128
1999	Wet	111	237	17	112
2000	Average	15	325	25	59
2001	Below average	6	276	83	0

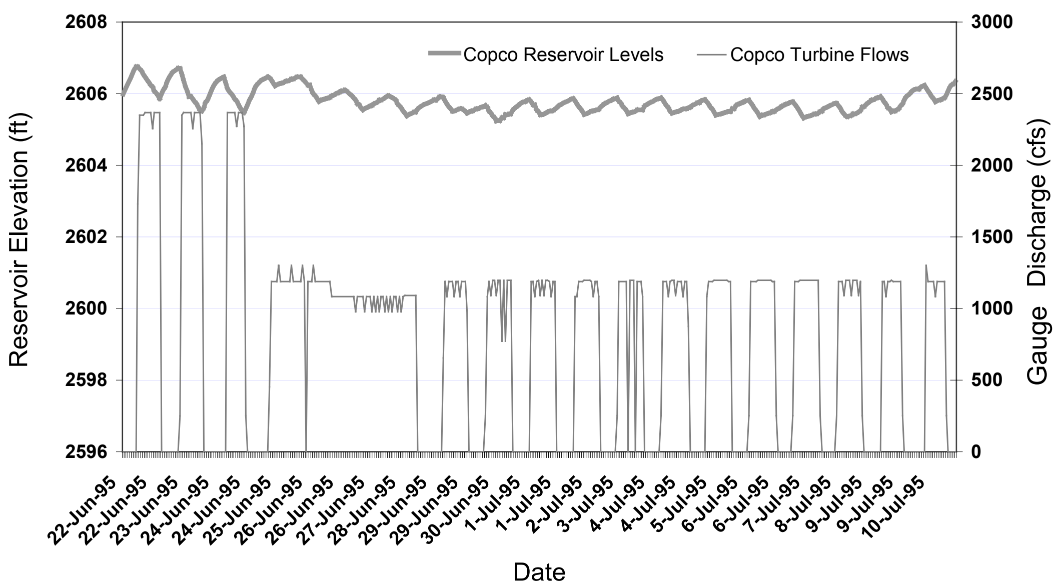


Figure E3.1-16. Hourly Copco No. 1 reservoir elevations and Copco No. 1 powerhouse discharge during June 22-July 10, 1995.

Flow Conditions and Minimum Instream Flows in the Copco Bypass Reach

The relatively short reach of the Klamath River between Copco No. 2 dam and powerhouse is referred to as the Copco bypass reach (RM 196.8 to 198.3). No major tributaries occur in this Copco bypass reach, and there are no existing instream flow or ramp rate requirements. PacifiCorp maintains a minimum instream flow of 5 to 10 cfs as a standard operating practice.

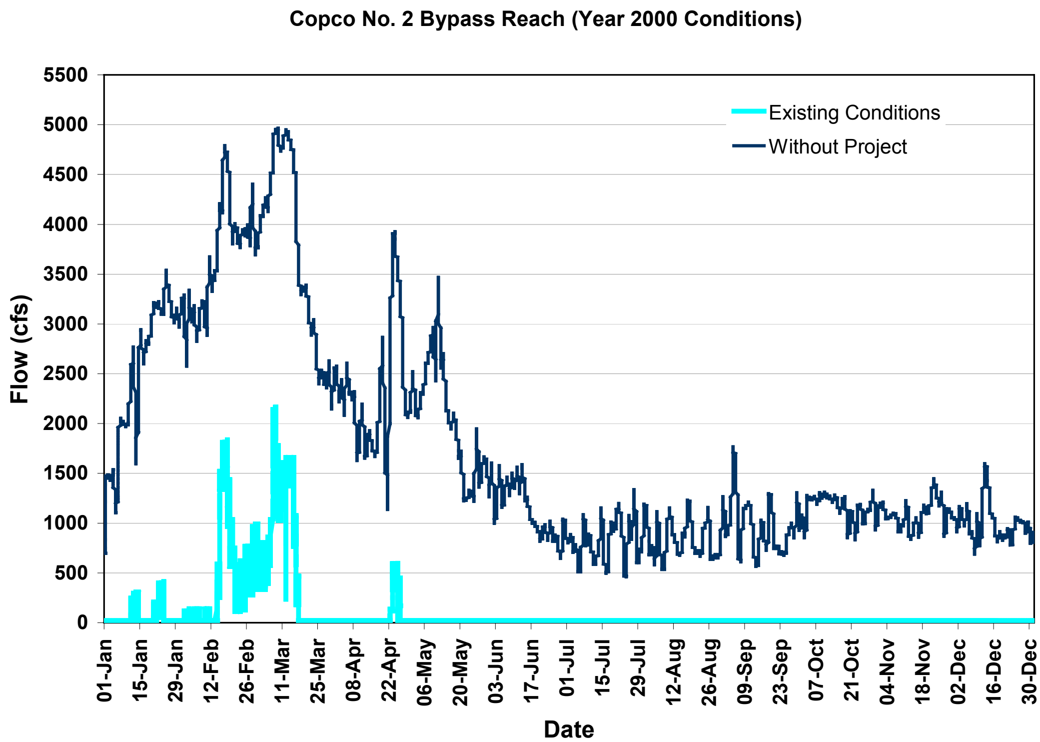
Modeled Project Effects

Graphs of RMA-2 model output of hourly flow (cfs) in the Klamath River at Copco No. 1 dam are shown for existing conditions, steady flow, and the two without-Project scenarios (WOP and WOP II) in the Water Resources FTR, Appendix 5C. RMA-2 was not used to specifically model the relatively short 1.5-mile Copco bypass reach. Therefore, to represent existing conditions, flows for the bypass reach were conservatively estimated by subtracting a continuous diversion of up to 3,200 cfs (i.e., the Copco No. 2 powerhouse hydraulic capacity) from the modeled flows at Copco No. 1 dam. In addition, a minimum instream flow of about 10 cfs was assumed in the bypass reach.

Graphs comparing estimated flow for existing conditions and WOP scenarios in the Copco bypass reach (about RM 197) are shown in Figure E3.1-17 for 2000 and 2001 conditions. Graphs comparing model output of flow for existing conditions and WOP scenarios in the Klamath River just below the Copco No. 2 powerhouse (RM 196.7) are shown in Figure E3.1-18 for 2000 and 2001 conditions. The Klamath River just below the Copco No. 2 powerhouse (RM 196.7) is actually at the head end of Iron Gate reservoir, and therefore is not actually a riverine section.

Figure E3.1-17 illustrates the reduction in flows in the Copco bypass reach from diversion of flow at Copco No. 2 dam to the power conduit and powerhouse. Compared to WOP conditions, the magnitude of this diversion varies up to 3,200 cfs (the Copco No. 2 powerhouse hydraulic capacity). During 2000, spill from Copco No. 1 and No. 2 dams occurred between mid-February and mid-March, resulting in a flow of up to about 2,000 cfs in the bypass reach. At all other times in 2000 and throughout 2001, only the minimum flow occurred in the bypass reach.

Figure E3.1-18 illustrates the fluctuation in flows below the Copco No. 2 powerhouse under existing conditions from hydropeaking operations at Copco No. 2 powerhouse when river flows are less than about 3,200 cfs. During 2000, river flows exceeded 3,200 cfs from about mid-January through March, during which time the Copco No. 2 powerhouse was generating continuously and spill up to about 5,000 cfs was occurring at Copco No. 1 and No. 2 dams. During the remainder of 2000, peaking operations occurred, except for brief periods in early September and November. When peaking operations occurred, the peaking took place daily and flows varied from a base flow of about 20 cfs to generation flows of about 2,600 cfs to 3,000 cfs. During 2001, river flows remained below 3,200 cfs and peaking operations occurred throughout the year except for brief periods in January, May, June, October, and November.



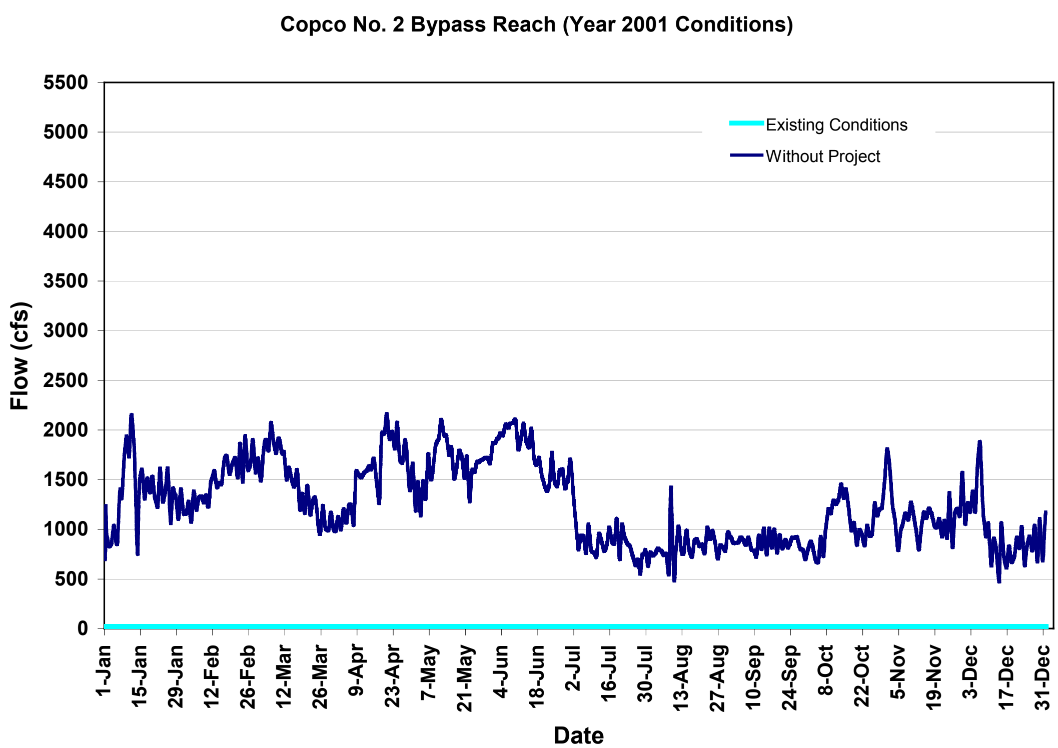
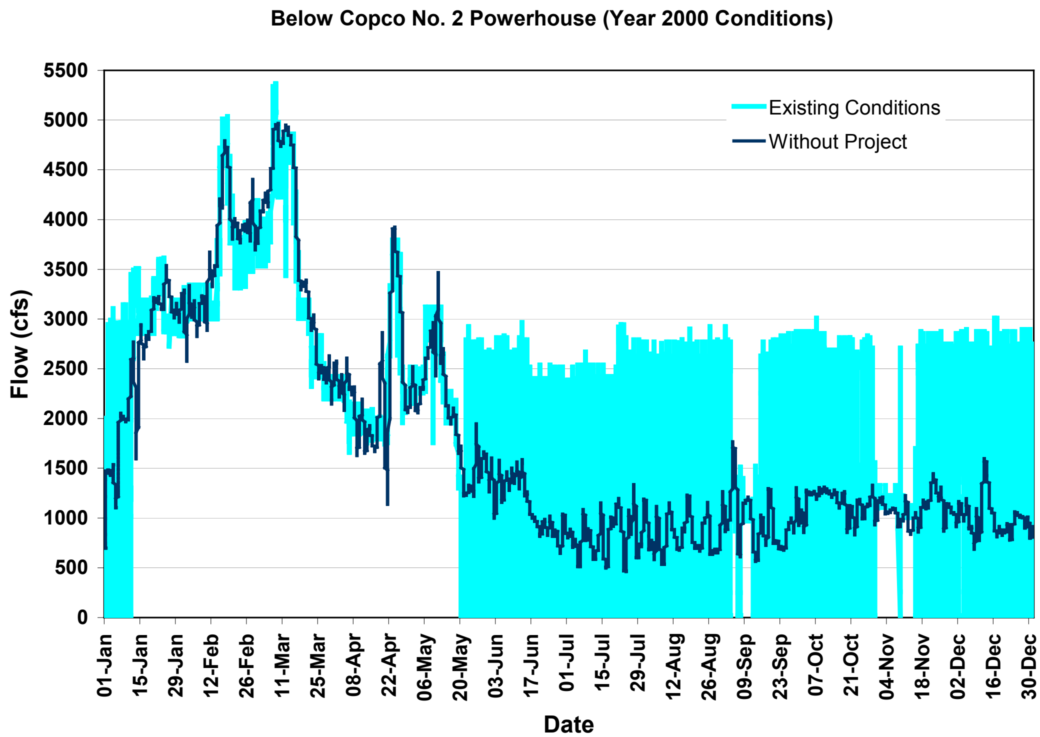


Figure E3.1-17. RMA-2 model annual time series output of hourly flow in the Klamath River in the Copco No. 2 bypass reach for 2000 (top plot) and 2001 (bottom plot) for existing conditions and a hypothetical without-Project scenario (WOP).



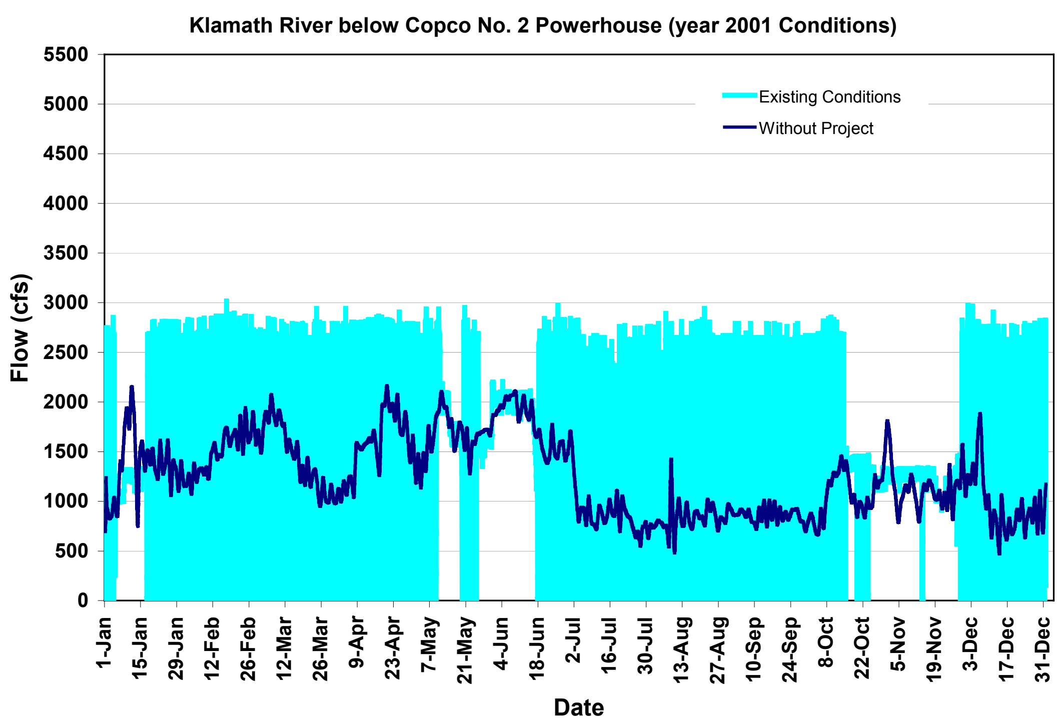


Figure E3.1-18. RMA-2 model annual time series output of hourly flow in the Klamath River below the Copco No. 2 powerhouse in 2000 (top plot) and 2001 (bottom plot) for existing conditions and a hypothetical without-Project scenario (WOP).

E3.1.5.5 Iron Gate

Flow-Related Operations and Minimum Instream Flow Releases at the Iron Gate Development

The Iron Gate Development consists of Iron Gate reservoir, dam, and powerhouse. The Iron Gate reservoir includes the portion of the mainstem Klamath River from Iron Gate dam (RM 190) to the upper end of the Iron Gate reservoir at about RM 196.8. Iron Gate reservoir typically fluctuates about 4 feet annually between normal minimum and full pool elevations (Figure 3.1-19). Because of its relatively small active storage, Iron Gate reservoir has a modest effect on the general shape and peak magnitude of annual hydrographs (Figure E3.1-19). Characteristics of Iron Gate reservoir reservoir and its storage capacity are listed in Table E3.1-12.

The Iron Gate powerhouse is located at the base of Iron Gate dam. Iron Gate is generally operated in a relatively constant generation mode to provide stable flows below Iron Gate dam. Spill generally occurs during the winter and spring months when river flows exceed the turbine hydraulic capacity (about 1,735 cfs) (Figure 3.1-20).

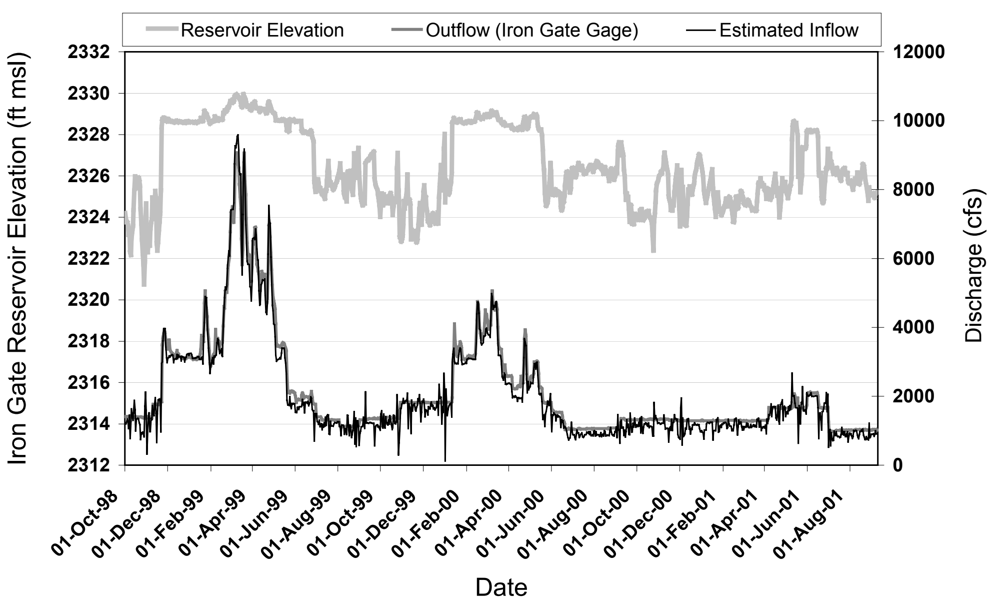


Figure E3.1-19. Daily average Iron Gate reservoir elevation and estimated reservoir inflow and outflow for Water Years 1999-2001.

Table E3.1-12. Iron Gate reservoir physical and operational characteristics.

Impoundment length (miles)	6.8	Normal full pool elevation (feet msl)	2,328.0
Impoundment length (RM)	190-196.8	Normal minimum pool elevation (feet msl)	2,324.0
Surface area (acres)	944	Normal annual operating fluctuation (feet)	4.0
Maximum / mean depth (feet)	167/62	Average daily operating fluctuation (feet)	0.5
Total storage capacity (ac-ft)	58,794	Normal active storage capacity (ac-ft)	3,790
Total retention time (days)		Active storage retention time (days)	
At 710 cfs	42	At 710 cfs	2.7
At 1,600 cfs (≈ mean flow)	16	At 1,600 cfs (≈ mean flow)	1.0
At 10,000 cfs (extreme event)	3	At 10,000 cfs (extreme event)	0.2

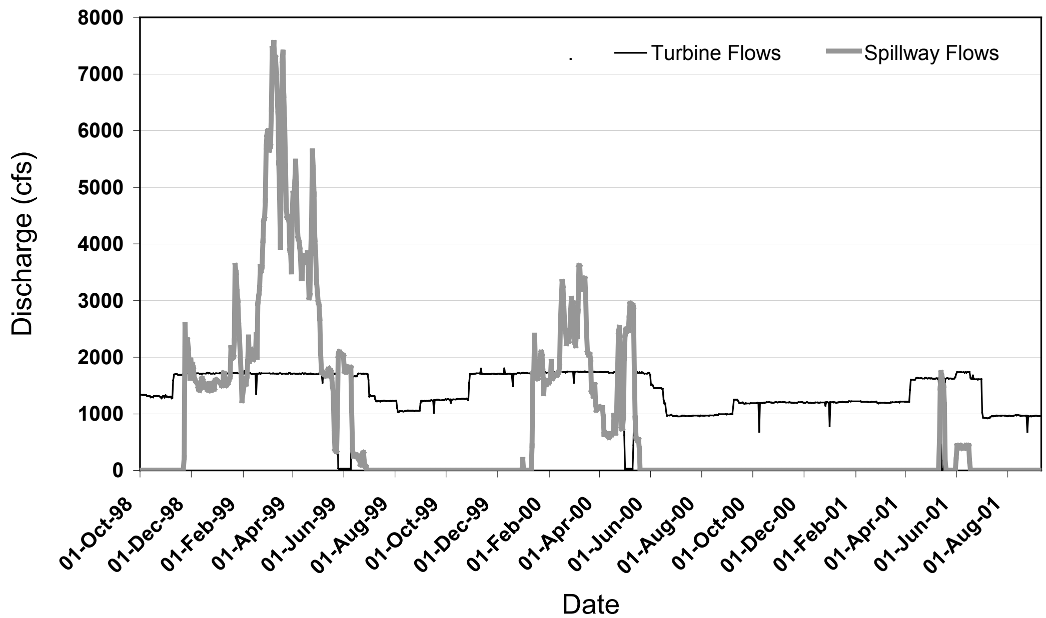


Figure E3.1-20. Daily average spillway and turbine discharges from the Iron Gate dam and powerhouse for Water Years 1999-2001.

FERC-stipulated minimum flow requirements are 1,300 cfs from September through April, 1,000 cfs in May and August, and 710 cfs in June and July. Since 1996, however, USBR's annual Project Operations Plans have dictated instream flow releases. The latest Klamath Irrigation Project 2003 Operations Plan (April 10, 2003) states that USBR will ensure that Klamath River flows at Iron Gate dam will meet or exceed the flows listed in Table E3.1-13.

Table E3.1-13. Klamath River flows at Iron Gate dam stipulated in USBR's Klamath Irrigation Project 2003 Operations Plan (April 10, 2003).

	Water Year Type				
Period	**Wet**	**Above Average**	**Average**	**Below Average**	**Dry**
April 1-15	5,932	2,955	1,863	1,826	822
April 16-30	5,636	2,967	2,791	1,431	739
May 1-15	3,760	2,204	2,784	1,021	676
May 16-31	2,486	1,529	1,466	1,043	731
June 1-15	1,948	1,538	829	959	641
June 16-30	1,921	934	1,163	746	617
July 1-15	1,359	710	756	736	516
July 16-31	1,314	710	735	724	515
August	1,149	1,039	1,040	979	560
September	1,341	1,316	1,300	1,168	731
October	1,430	1,346	1,345	1,345	907
November	1,822	1,414	1,337	1,324	899
December	1,822	1,387	1,682	1,621	916
January	2,792	1,300	3,618	1,334	1,030
February	4,163	1,300	1,300	1,806	673
March 1-15	8,018	1,953	2,143	2,190	688
March 16-31	6,649	4,009	2,553	1,896	695

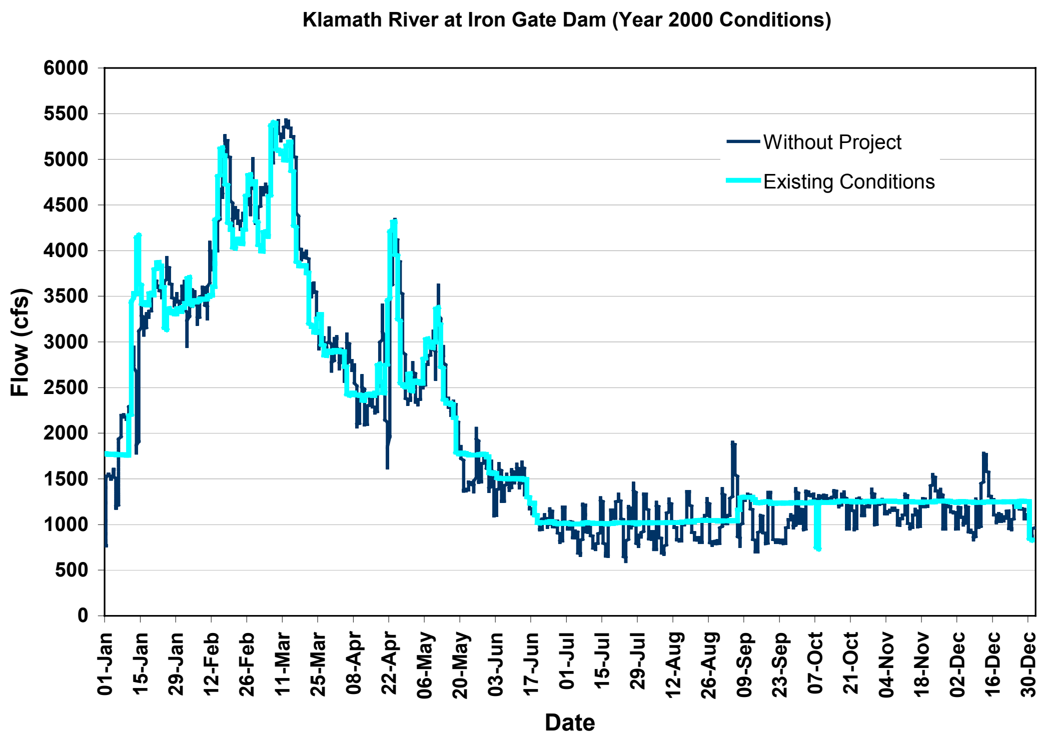
FERC-stipulated changes in flow rate (i.e., ramp rate) caused by releases at Iron Gate dam and powerhouse are limited to the lesser of a 3-inch-per-hour or 250-cfs-per-hour rate. However, USBR's 2003 Operations Plan includes the following downramping criteria at Iron Gate dam: (1) decreases in flows of 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period when Iron Gate dam flows are above 1,750 cfs; and (2) decreases in flow of 150 cfs or less per 4-hour period and no more than 50 cfs per 2-hour period when Iron Gate dam flows are 1,750 cfs or less. These ramp rates are consistent with those stipulated by USFWS and NOAA–Fisheries in USBR's 2002 BO.

<u>Modeled Project Effects</u>

Graphs of RMA-2 model output of hourly flow (in cfs) in the Klamath River at Iron Gate dam (RM 190) and at Seiad Valley (RM 129) are shown for existing conditions, steady flow, and the two without-Project scenarios (WOP and WOP II) in the Water Resources FTR, Appendix 5C. Of the four scenarios, the comparison between existing conditions and WOP scenarios shown in those figures best illustrates the effects on flow caused by Project facilities and operations in the Klamath River downstream of Iron Gate dam. Graphs comparing model output of flow for existing conditions and WOP scenarios in the Klamath River at Iron Gate dam (RM 190) are shown in Figure E3.1-21 for 2000 and 2001 conditions. Graphs comparing model output of flow for existing conditions and WOP scenarios in the Klamath River at Seiad Valley (RM 129) are shown in Figure E3.1-22 for 2000 and 2001 conditions.

In general, the Iron Gate facilities and operations have a regulating effect on the magnitude and duration of flows when compared to WOP conditions. The Iron Gate reservoir acts to moderate flow fluctuations entering the reservoir from Copco No. 2 powerhouse operations, especially when the Copco No. 2 powerhouse is operated in peaking mode (see Figure E3.1-20). This reflects that Iron Gate dam and powerhouse are operated to provide relatively stable instream flow releases to the river according to annual operations plans for the Klamath Irrigation Project, based on current and expected hydrologic conditions and consistent with BOs[9] issued by USFWS and NOAA-Fisheries. A similar regulation and moderation effect is illustrated in Figure E3.1-22 in the Klamath River at Seiad Valley, although significant accretion is evident, particularly during winter and spring, from the much larger basin drainage area that contributes flows to the river at Seiad Valley.

[9] USFWS and NOAA-Fisheries Biological Opinions on Klamath Irrigation Project Operations.



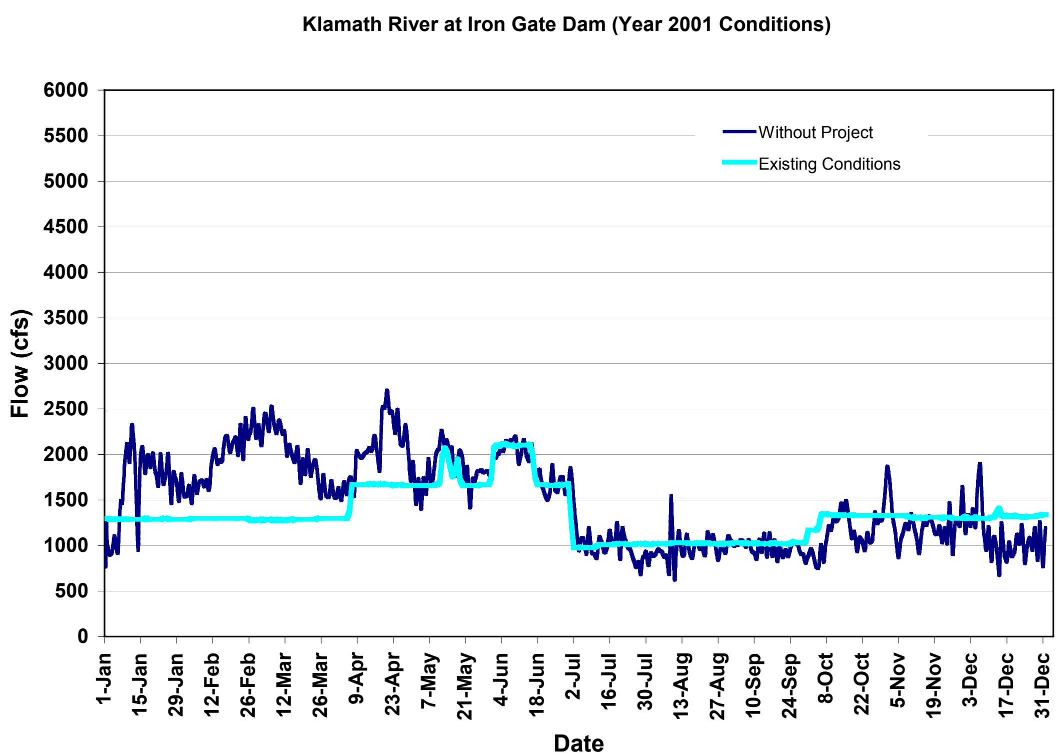
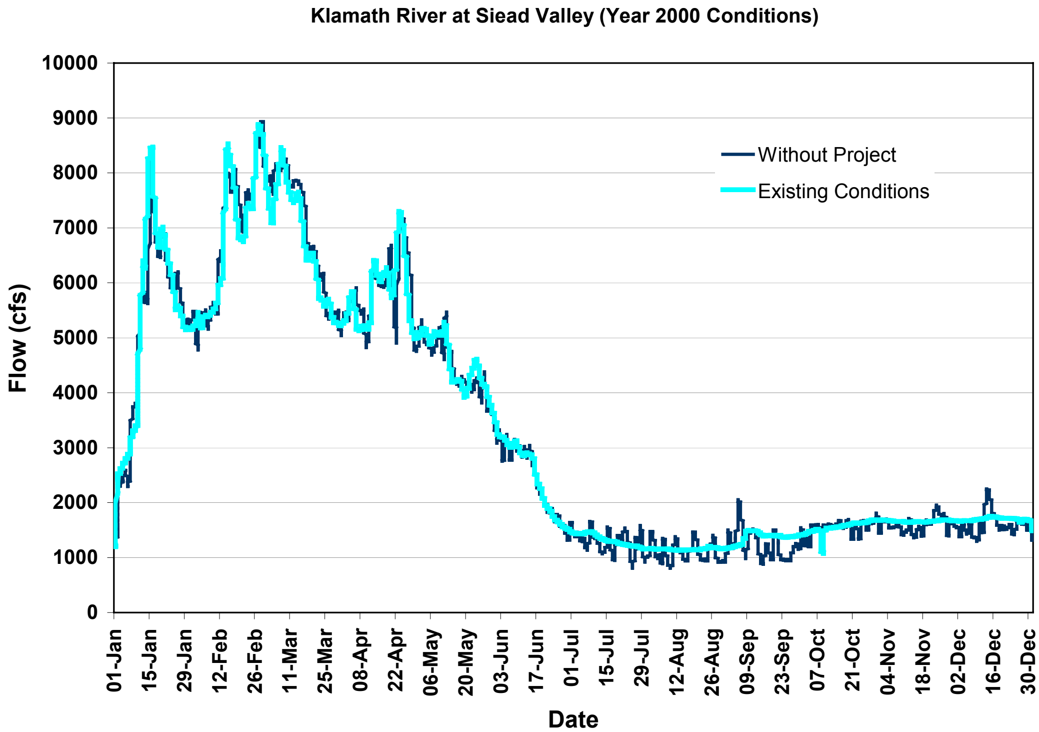


Figure E3.1-21. RMA-2 model output of hourly flow for 2000 and 2001 in the Klamath River below Iron Gate dam for existing conditions and a hypothetical without-Project scenario (WOP). The model output is displayed as an annual time series for 2000 in the top plot and for 2001 in the bottom plot.



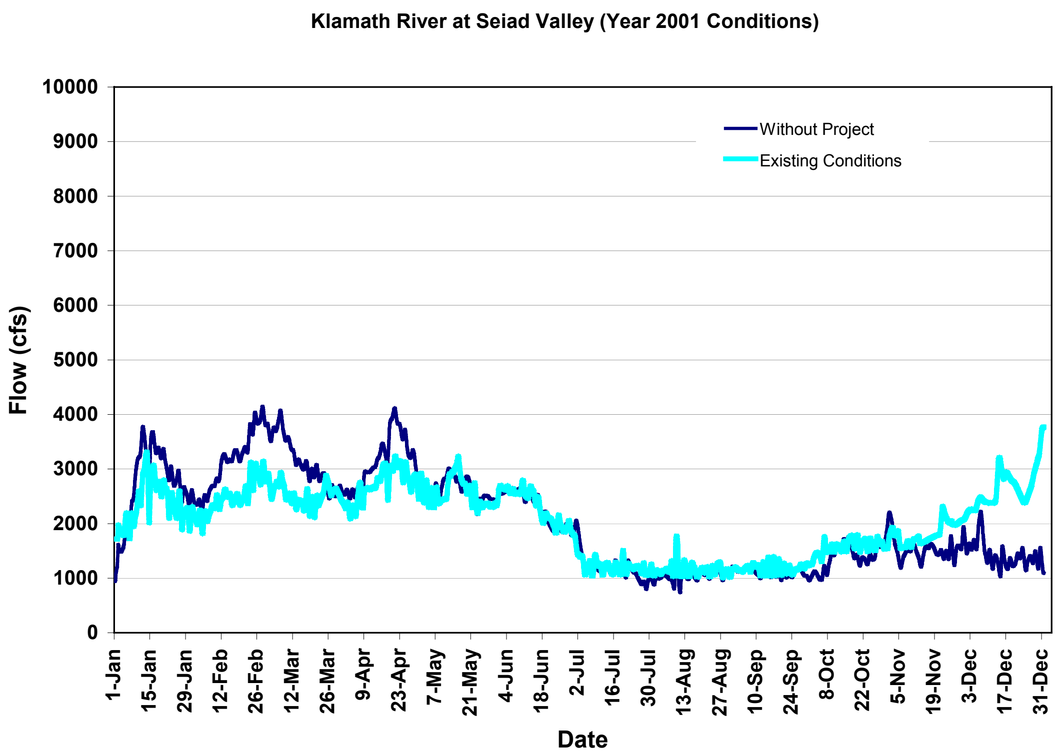


Figure 3.1-22. RMA-2 model output of hourly flow for 2000 and 2001 in the Klamath River at Seiad Valley for existing conditions and a hypothetical without-Project scenario (WOP). The model output is displayed as an annual time series for 2000 in the top plot and for 2001 in the bottom plot.

Flow Conditions in the Klamath River Below Iron Gate Dam

This reach includes the Klamath River downstream of Iron Gate dam. Most of the discussion presented below focuses on the Klamath River from Iron Gate dam (RM 190) to Seiad Valley at about RM 129. The upstream flow condition for the Iron Gate dam (RM 190.1) to Seiad Valley (RM 129) reach consists predominantly of releases from Iron Gate reservoir. The Shasta and Scott rivers are two primary tributaries within the reach, entering at approximately RM 176 and RM 143, respectively. Smaller notable tributaries include Bogus, Cottonwood, Beaver, Horse, Seiad, and Grider creeks.

Accretion of flow in the reach varies by time of year and runoff conditions. Between Iron Gate dam and Seiad Valley, the total mean annual flow approximately doubles, with the bulk of the inflow contributed by the Scott River. During high flow conditions, peak flows can increase two- to three-fold between Iron Gate dam and Seiad Valley (compare flow peaks in Figure E3.1-23). However, during summer low flow periods, the river flow does not substantially increase (compare low flows in Figure E3.1-23).

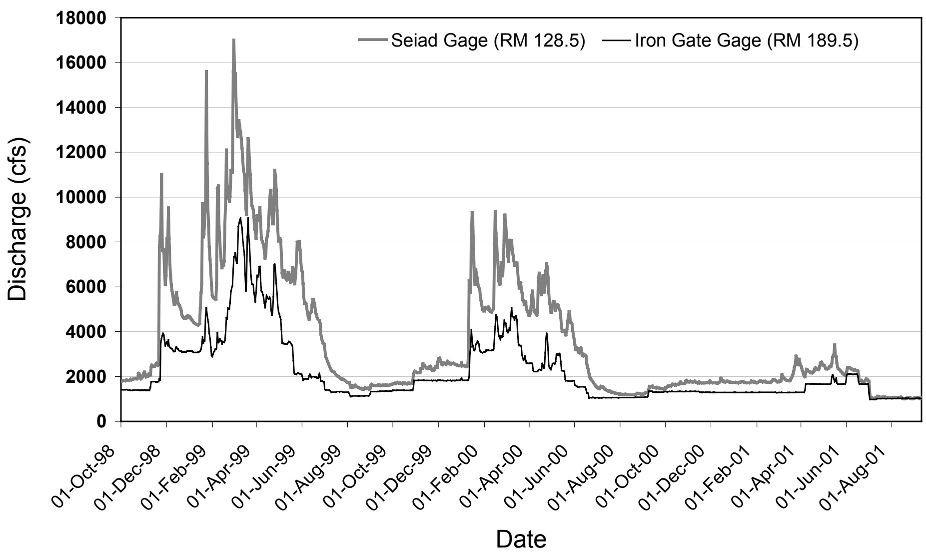


Figure E3.1-23. Daily average Iron Gate and Seiad Valley discharge for Water Years 1999-2001.

Klamath River Flows at Iron Gate: Contribution to Total Basin Flows

The total drainage area of the Klamath River basin is about 12,100 square miles (as measured at RM 5.9 at USGS Gauge No. 11530500 at Klamath, California). The drainage basin area upstream from Iron Gate dam covers 4,630 square miles, extending throughout Klamath County, Oregon, and Siskiyou County, California. The drainage basin areas upstream from the J.C. Boyle powerhouse and Keno dam cover about 4,080 and 3,920 square miles, respectively, within Klamath County. However, the operations and diversions for irrigation and wildlife refuge maintenance from Upper Klamath Lake largely control drainage flows within the basin. Ninety-eight percent of the available 499,074 ac-ft of active storage on the Klamath River above Iron Gate dam is contained in Upper Klamath Lake.

Table E3.1-14 summarizes the drainage area and the period of record for USGS gauges for the Klamath River and major tributaries downstream of the Project area. Data from these gauges were used to compare contribution of flow measured at Klamath River below Iron Gate dam (and key tributaries and accretions) to flow measured at Klamath River near the mouth (at Klamath, California). Results are depicted in Figure E3.1-24 for Water Year 1992, a critically dry water year. The results indicate that the contribution of flow at Iron Gate dam to flow near the mouth varies substantially on a seasonal basis—from only a few percent during the higher flow spring period to about 45 percent during the low flow summer period.

Table E3.1-14. Other USGS flow gauging data for the Klamath River and major tributaries downstream of the Project area.*

USGS Gauges in California	Drainage Area (square miles)	Gauge Number	Period of Record
Shasta River near Yreka	793	11517500	10/01/1933-present
Scott River near Fort Jones	653	11519500	10/01/1941-present
Klamath River near Seiad Valley	6,940	11520500	10/01/1921-present
Salmon River at Somes Bar	751	11522500	10/01/1911-present
Klamath River at Orleans	8,475	11523000	10/01/1927-present
Klamath River near Klamath	12,100	11530500	10/01/1910-present

*Includes only those gauges that have a period of record extending to present.

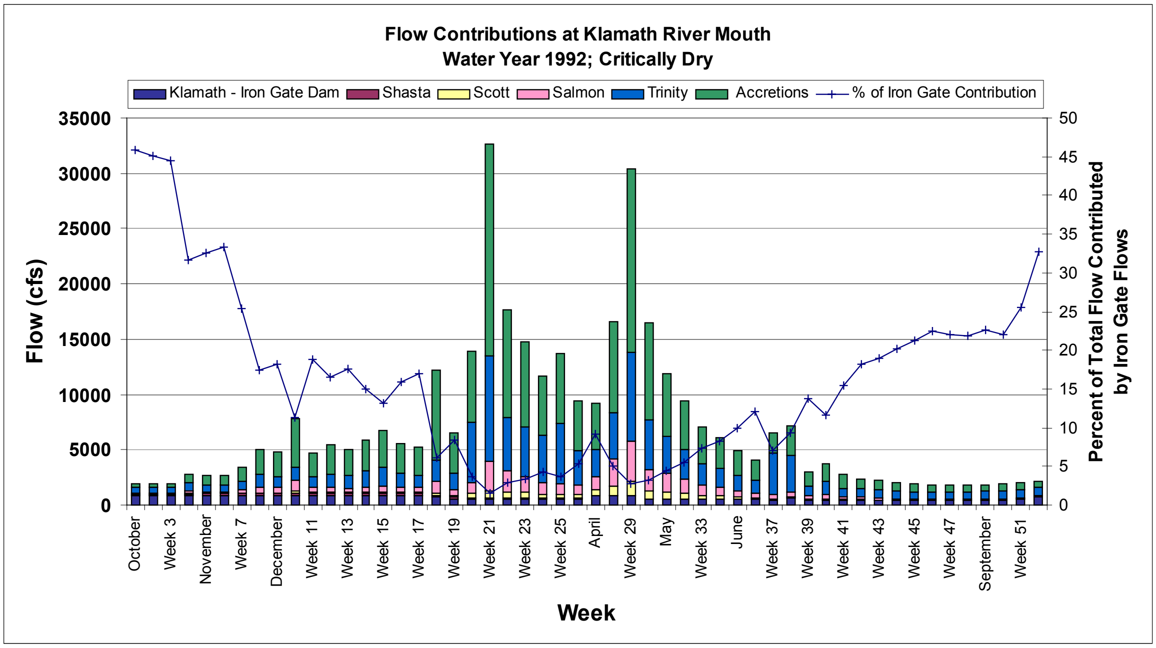


Figure E3.1-24. Contribution of flow measured at Klamath River below Iron Gate dam (and key tributaries and accretions) to flow measured at Klamath River near the mouth (at Klamath, California).

E3.1.5.6 Fall Creek

The FERC license minimum flow requirements are 0.5 cfs at all times from the Fall Creek dam into Fall Creek, and a 15-cfs continuous flow in Fall Creek (or a quantity equal to the natural stream flow, whichever is less) downstream of the powerhouse.

E3.1.6 Proposed Uses of Waters in the Project Area

PacifiCorp proposes to continue operations at the J.C. Boyle, Copco No. 1, Copco No. 2, Iron Gate, and Fall Creek developments (see Exhibit A for descriptions of these proposed operations). Instream flow and ramping rate measures applicable to the various reaches affected by the proposed Project are described in section E3.8 by Project development or major river reach. Adjustments in peaking operations at the J.C. Boyle powerhouse and resultant flows in the J.C. Boyle peaking reach are also described in section E3.8. For additional discussion of these flow measures, the reader is referred to section E4.8 of this Exhibit E. Also as described in section E4.8, PacifiCorp has agreed to continue requested analysis and discussion with stake-holders on instream flow needs for aquatic resources. Based on this continued analysis and discussions, PacifiCorp may choose to formally modify its proposed flow and ramping rate measures.

The East Side and West Side facilities will be decommissioned. Current operations of the East Side and West Side facilities divert flows from a portion of Link River as described in section E3.1. With the proposed measures, such flow diversions will end. As described in Exhibit A, PacifiCorp is not seeking to include the Keno facility in the new FERC license for the Project. Therefore, Keno will no longer be operated to provide water storage or flows for Project hydropower generation.

E3.1.7 PacifiCorp's Project Water Rights

E3.1.7.1 Project Water Rights in Oregon

Oregon's water laws are based on the system of prior appropriation, and Oregon water rights are controlled by state law and administered by the Oregon Water Resources Department (OWRD). Some of the Oregon facilities within the Project use water pursuant to rights that have been recognized, quantified, and certificated under Oregon law. Other facilities operate with water rights perfected before Oregon's Water Code was enacted in 1909; these rights are currently being determined in a general stream adjudication for the Klamath basin.

State of Oregon Hydropower Permits

Hydropower water rights in Oregon are governed by Oregon Revised Statutes (ORS) Chapter 543 and Chapter 543A, pursuant to which hydropower generators may operate under either a "Power Claim" or a "Hydroelectric License." Both types of permit require payment of annual fees to OWRD. Functionally, there are two types of Power Claims. A hydropower water right that was developed before 1909 and is unadjudicated may be recognized as a Power Claim; the water rights associated with such claims are vested but inchoate, not limited or subordinated to other water uses, and assumed to be perpetual. Hydropower water rights developed from 1909 through 1931 are also subject to Power Claims and are given a perpetual, certificated water right. Such certificates typically contain a subordination clause making the right subject and subordinate to junior as well as senior irrigation water rights. Neither unadjudicated nor certificated Power Claims require reauthorization by the state. Since 1932, the use of water for hydropower generation has been governed by the state Hydroelectric License, which is a time-limited permit to use water for hydropower purposes and does not include a separate certificated water right until after it is reauthorized pursuant to ORS Chapter 543A. Hydroelectric Licenses contain limitations similar to the subordination clauses found in Power Claim certificates and, because they are time-limited, are subject to reauthorization by the state.

PacifiCorp holds all three different types of licenses permitting the use of water to generate electricity. Specifically, the Oregon water rights and hydroelectric permit types for each of the Oregon facilities within the Project may be summarized as follows.

East Side Powerhouse

State of Oregon Certificate of Water Right No. 24508 certifies the right to use 1,000 cfs of the waters of the Link River (Klamath River) at East Side powerhouse for the purpose of development of electricity, with a priority date of February 24, 1919. The state permits this use through Power Claim No. 667. The certificate contains a subordination clause in which the right is “made subject and subordinate in right and time to any appropriations of water which may hereafter be made at points above on Upper Klamath Lake or its tributaries, for irrigation, or for storage for irrigation purposes for use on lands in Oregon.”

The East Side power plant also generates with a second, unadjudicated water right for 150 cfs, which is permitted under Power Claim No. 34. This unadjudicated right is further discussed below.

West Side Powerhouse

The West Side power plant generates electricity with 205 cfs, an unadjudicated water right which is further discussed below. The State of Oregon permits this use through Power Claim No. 35. PacifiCorp also holds an unadjudicated, nonhydropower water right for irrigation at the plant operator’s cottage located at this facility.

J.C. Boyle Dam and Powerhouse

Water for generation at the J.C. Boyle facility is permitted through State of Oregon Hydropower License No. HE 180 (HE 180), issued in 1956 for the period between January 1, 1957, and December 31, 2006. Article 9 of the license provides for use of 2,500 cfs from the Klamath River for hydroelectric power at the plant. The water right has a priority date of April 17, 1951, and is vested in the licensee during the period of the license as well as any renewal. The use of water under HE 180 is subject to any junior water right permit for “domestic, stock or irrigation purposes” issued after April 17, 1951. In addition, the right is subject to bypass limitations. Specifically, Article 3 of the license requires up to 150 cfs to be bypassed for the “preservation of fish” and for a minimum flow of 200 cfs to be maintained below the powerhouse.

Fall Creek Powerhouse

The Fall Creek hydroelectric facility is located in California; however, the plant uses water that is diverted in Oregon from Spring Creek (a tributary of Jenny Creek, which is a tributary of the

Klamath River) into a canal that runs into Fall Creek above the powerhouse. The Oregon water right, for 16.5 cfs, is unadjudicated and is discussed further below. The water right is not subject to a state Power Claim or Hydroelectric License because ORS Chapters 543 and 543A apply to the generation of electricity rather than specifically to the diversion of water, and they do not have extraterritorial application.

Unadjudicated Oregon Water Right Claims

The state is currently adjudicating pre-1909 water rights in the Klamath River basin. The contest period closed in May 2000 and the adjudication is ongoing. PacifiCorp has made claim to four hydropower rights or rights associated with hydropower facilities. For each claim, PacifiCorp has completed the evidentiary hearing (or stipulation) process, and each claim has been recommended, in a proposed final order issued by a hearing officer from the Hearing Officer Panel, for the amounts listed below in the following summaries of the four unadjudicated claims.

Claim No. 168

Source	Link River
Type of Use	Power – West Side powerhouse
Priority Date	December 11, 1891
Rate of Diversion	205 cfs
Status of Claim	Hearing Officer issued Proposed Final Order to Adjudicator.

Claim No. 164

Source	Link River
Type of Use	Irrigation for operator's cottage
Priority Date	December 11, 1891
Rate of Diversion	.01 cfs
Status of Claim	Hearing Officer issued Proposed Final Order to Adjudicator.

Claim No. 167

Source	Link River
Type of Use	Power – East Side powerhouse
Priority Date	November 1, 1895
Rate of Diversion	150 cfs
Status of Claim	Hearing Officer issued Proposed Final Order to Adjudicator.

Claim No. 218

Source	Spring Creek
Type of Use	Power (Fall Creek facility)
Priority Date	September 23, 1902
Rate of Diversion	16.5 cfs
Status of Claim	Hearing Officer issued Proposed Final Order to Adjudicator.

PacifiCorp's unadjudicated claims will become enforceable water rights when the Adjudicator issues a Final Order. It is unclear when a Final Order will be issued, however, because many claims and contests have yet to be heard and OWRD has not provided a schedule for issuing a Final Order. The Final Order will be reviewed by the Klamath County Circuit Court and that court will issue a final decree. The decree can be appealed. Final resolution of the Klamath adjudication likely is years away. Oregon law provides that pre-1909 water rights are vested rights. PacifiCorp is entitled to use the water under the unadjudicated claims while a final order is pending.

Reauthorization of Oregon Hydropower License No. 180

HE 180 is a state hydropower license that includes a time-limited water right for the generation of electricity at the J.C. Boyle facility. HE 180 is subject to reauthorization by the state of Oregon. Oregon law requires that the state "shall issue a water right for continued operation of an existing hydroelectric project upon a finding that the proposed use will not impair or be detrimental to the public interest . . . ." ORS 543A.025(1). The quoted statute provides several factors the state must consider in making its finding. Those factors are addressed in the following discussion.

ORS 543A.025(1)(a)

PacifiCorp's use of water under HE 180 conserves the highest use of such water for all purposes. First, the water right is subject to all prior rights to water on the Klamath River and is also made expressly subordinate to junior water rights for "domestic, stock or irrigation purposes." Thus, no upstream water users for domestic, stock watering, or irrigation purposes are affected by HE 180. Because the use is nonconsumptive, no downstream users are affected. Second, HE 180 requires bypass flows and the maintenance of instream flows below the powerhouse. These requirements, along with ramping limitations, ensure the protection of both aquatic wildlife and recreational use.

ORS 543A.025(1)(b)

PacifiCorp's use of water under HE 180 maximizes the economic development of that resource. PacifiCorp manages and operates the J.C. Boyle facility, in conjunction with all other Project facilities, to utilize water efficiently for hydroelectric generation, as well as to protect and conserve such water for other beneficial uses, as discussed above. PacifiCorp's operation of Project facilities produces numerous economic benefits, such as the provision of local employment, contribution to the local tax base, and the availability of electricity at reasonable rates.

ORS 543A.025(1)(c)

PacifiCorp's operation of Project facilities controls the water used at the J.C. Boyle facility to provide several resource benefits to the public, including minor flood control and recreational opportunities. For example, the Bureau of Land Management (BLM) manages a segment of the Klamath River downstream of the J.C. Boyle facility under the federal Wild and Scenic Rivers Act. The managed segment is popular for whitewater rafting and other recreation; PacifiCorp supports such recreational use in consideration of flow (generation) timing of releases downstream of J.C. Boyle and by providing and maintaining a number of recreational facilities, such as take-out points for rafters in the California segment of that reach of the Klamath River.

ORS 543A.025(1)(e)

Because PacifiCorp manages and operates the J.C. Boyle facility efficiently for hydroelectric generation and, because of the resource and economic benefits from Project operations that are described above, the use of water under HE 180 prevents wasteful, uneconomic, impracticable, or unreasonable use of this resource.

ORS 543A.025(1)(f)

PacifiCorp's use of water under HE 180 protects vested and inchoate rights to water or its use. Under the prior appropriation system, PacifiCorp's rights are subordinate to all prior rights to water on the Klamath River, which includes all rights perfected before April 17, 1951. Vested and inchoate water rights on the Klamath River are now in the process of being adjudicated (see discussion above); until the adjudication is complete, holders of those rights cannot have PacifiCorp's rights enforced against them, pursuant to OWRD policy. In addition, the express terms of HE 180 make PacifiCorp's use of water subject to junior water rights for "domestic, stock or irrigation purposes" and to bypass and instream flow requirements. Thus, no upstream water users for domestic, stock watering, or irrigation purposes are affected by HE 180, whether their water rights are junior or senior to PacifiCorp's. Because the use is nonconsumptive, no downstream users are affected either.

ORS 543A.120(2)(b)

PacifiCorp's use of water at the J.C. Boyle facility and other Project facilities is compatible with applicable basin programs and land use plans. First, the state of Oregon implements its statewide water allocation policies through individual "basin plans" established by administrative rules promulgated by the Oregon Water Resources Commission. The Commission has not adopted a basin plan for the Klamath basin, however, so use of the waters of the Klamath River is subject to general statutes and rules, including ORS 542.620. PacifiCorp's use of water under HE 180 complies with such statutes and rules. For example, PacifiCorp's use of water throughout the Project represents an efficient use of that resource for hydroelectric generation, as mandated by ORS 542.620, Article IV. Second, Klamath County's Comprehensive Plan establishes goals for the use of land and resources in the county. For example, Policy 1 of Goal 13: Energy Conservation portion of the Comprehensive Plan states: "The County shall encourage the use of renewable and efficient energy sources in residential, commercial, and industrial development." PacifiCorp's nonconsumptive use of water as a renewable energy source at Project facilities is compatible with this goal.

Because PacifiCorp's use of water under HE 180 meets the public interest and other requirements set forth in ORS Chapter 543A, PacifiCorp anticipates that the state of Oregon will reauthorize the license.

E3.1.7.2 Project Water Rights in California

The water rights for the Project in California were established pursuant to the laws of the state of California by PacifiCorp's predecessors in interest and described as follows:

- State of California Water Right No. Fall1000 is a pre-1914 appropriative right to use 25 cfs of Fall Creek for hydroelectric generation, with a priority date of May 13, 1902.

- State of California Water Right No. Fall3000 is a pre-1914 appropriative right to use 75 cfs of Fall Creek water for hydroelectric generation, with a priority date of July 3, 1902.

- State of California Water Right No. S012966 is for 10 cfs from an unnamed tributary to Fall Creek for the fish hatchery at the Fall Creek Hydroelectric Project with a priority date of January 1, 1979. The California Department of Fish and Game (CDFG) diverts the water on behalf of PacifiCorp.

- State of California Water Right No. COPCO400000 is a pre-1914 right to use 10,000 cfs of Klamath River water for hydroelectric generation at Copco No. 1 and Copco No. 2, with a priority date of February 13, 1909.

- State of California Water Right No. COPCO150000 is a pre-1914 right to use 3,750 cfs of Klamath River water for hydroelectric generation at Copco No. 1 and Copco No. 2, with a priority date of February 4, 1911.

- State of California Water Right No. COPCO50000 is a pre-1914 right to use 1,250 cfs of Klamath River water for hydroelectric generation at Copco No. 1 and Copco No. 2, with a priority date of February 13, 1909.

- State of California Water Right No. A017527 is a March 26, 1957, priority right to use 3,300 cfs of Klamath River water for hydroelectric generation and storage, of which 50 cfs supplies the Iron Gate fish hatchery.

E3.2 REVIEW OF PREVIOUS WATER QUALITY INFORMATION

This section summarizes previous water quality data and information concerning the Project area. The discussion provides information from review of previous water quality studies[10] and from previous data collected by various entities in the Project vicinity. Section 2.0 of the Water Resources FTR provides additional details on the purpose, methods, and results of the compilation and review of previous water quality data.

E3.2.1 Previous Water Quality Studies in the Proposed Project Area

E3.2.1.1 J.C. Boyle Reservoir

The City of Klamath Falls (1986, 1990) conducted water quality sampling at sites in J.C. Boyle reservoir during 1984-1990 in conjunction with the Salt Caves Hydroelectric Project (proposed for construction near Stateline but never licensed or built). The City of Klamath Falls (1986, 1990) reported that the hydraulic residence time in the J.C. Boyle reservoir was sufficiently short that stratification did not typically occur, except for brief periods in summer when peaking

[10] PacifiCorp has also assembled a literature database (with abstracts) for aquatic resources within the Project area in preparation for its relicensing filing (Kier Associates, 2000). Numerous entries in this database are related to water use and quality and include the most current literature, as well as citations dating back to the 1950s. This database in available in CD format upon request from PacifiCorp (Todd Olson, 503-813-6657).
Several of the resource agencies also have dedicated pages of their Internet websites to information specific to the Klamath River basin, including the Project area. The most notable among these are sites maintained by USBR (http://www.mp.usbr.gov.kboa/esa), USGS (http://www.oregon.usgs.gov), and USFWS (http://www.r1.fws.gov), which provide access to numerous documents and abstracts related to water use and quality in the upper Klamath River.

operations and resultant reservoir releases were temporarily halted for annual maintenance purposes. The warmest surface water temperatures occurred during mid-July through early August.

The City of Klamath Falls (1986) reported that vertical profiles of dissolved oxygen in J.C. Boyle reservoir generally reflected the degree and duration of concurrent thermal stratification in the reservoir. Dissolved oxygen concentrations and percent saturation in J.C. Boyle reservoir were generally uniform with depth in 1984, reflecting a well-mixed, isothermal water column. In early July 1984, a brief period of thermal stratification occurred in J.C. Boyle reservoir, when peaking operations were temporarily halted for annual maintenance. As this brief period of thermal stratification developed, a vertical gradient in dissolved oxygen also developed, with a surface water concentration of 12.2 milligrams per liter (mg/L) (167 percent saturation) and a deep water concentration of 1.8 mg/L (23 percent saturation). When peaking operations resumed in mid-July, the reservoir returned to iso-oxic and isothermal conditions.

During 1965, Fortune et a1. (1966) observed differences in dissolved oxygen concentrations at three depths (surface, 15-foot level, bottom) in J.C. Boyle reservoir on seven dates sampled in June, July, and August, although the magnitude of these differences was quite variable between sampling dates. For example, a difference of nearly 10 mg/L was observed between surface and bottom waters on June 10, 1965, while differences of only about 1.0 mg/L were detected on two of three August sampling dates.

The City of Klamath Falls (1986) reported that, as with temperature and dissolved oxygen, values of pH in J.C. Boyle reservoir were uniform with depth, except in July 1984, when vertical stratification briefly developed. For example, on July 15, pH varied from 6.9 in bottom waters to 8.9 near the surface, suggesting relatively high algal photosynthetic activity in surface waters at the time. During all other sampling dates during 1984 and 1985, pH values generally remained uniform with depth, varying between 7 and 8.

The City of Klamath Falls (1986) compared suspended solids and turbidity data between sites upstream and downstream of J.C. Boyle reservoir and found that concentrations of suspended solids were slightly lower downstream on most sampling dates. A maximum suspended solids reduction of 27 percent was noted between the sites in October, but little, if any, reduction in turbidity was noted. Nutrient concentrations measured upstream and downstream of J.C. Boyle reservoir indicated that total phosphorus, soluble phosphorus, and nitrate were mostly reduced during reservoir throughflow. Based on these comparisons, the City of Klamath Falls (1986) concluded that J.C. Boyle reservoir acts mostly as a sink for suspended particulate materials, and for nitrogen and phosphorus by allowing settling of particulate matter, metabolism of organic compounds, and nutrient uptake by phytoplankton.

Blue-green algae mostly dominated the phytoplankton samples collected in J.C. Boyle reservoir during the summers of 1984 and 1985 (City of Klamath Falls, 1986). However, summer samples from J.C. Boyle reservoir differed from those of Copco and Iron Gate reservoirs in that diatoms were a much larger proportion of the phytoplankton. In addition to the differences in algal taxonomic composition, the concentrations of total algal biomass and chlorophyll *a* were also consistently lower in J.C. Boyle reservoir during the summer. This different composition was attributed primarily to the high diatom content of inflowing Klamath River periphyton coupled with J.C. Boyle reservoir's short hydraulic residence time and comparative lack of stratification. The City of Klamath Falls (1986) concluded that, because J.C. Boyle is a rapidly flushed, mainstem reservoir, its phytoplankton standing crop was more related to riverine input and transport than to processes occurring within the impoundment.

There was no distinct seasonal trend of coliform bacteria concentrations during the 1984-85 studies (City of Klamath Falls, 1986). However, peak concentrations generally occurred during July and August, when both water temperature and proportion of regional agricultural runoff were highest. Highest levels were typically observed upstream of J.C. Boyle reservoir, where mean probable numbers of coliforms occasionally exceeded 24,000 per 100 milliliter (ml) (Tables E3.2-1). Significantly lesser concentrations of coliform bacteria were observed at Klamath River sites downstream of J.C. Boyle reservoir, suggesting that the impoundment generally serves as an effective sink for coliform bacteria during the residence of waters in the reservoir. The City of Klamath Falls (1986) cited similar large declines in coliform bacteria that have been documented in other reservoir systems (Mikhailenko et al. 1978; Saleh, 1980, cited in City of Klamath Falls, 1986).

Table E3.2-1. Mean and range (in parentheses) of observed values for water quality parameters, Salt Caves Project, J.C. Boyle reservoir inflow and outflow sites, and surface and bottom waters, March 1984-February 1985.

Parameter (Units)	J.C. Boyle Reservoir Inflow	J.C. Boyle Reservoir Outflow	J.C. Boyle Reservoir Surface	J.C. Boyle Reservoir Bottom
Temperature (°C)	12.4 (0.8-23.0)	14.4 (4.0-23.0)	18.3 (11.5-25.8)	16.8 (11.2-23.0)
Dissolved Oxygen (mg/L)	8.9 (7.4-11.1)	8.8 (7.2-12.4)	8.9 (6.6-12.2)	7.2 (1.8-10.5)
Dissolved Oxygen (% saturation)	104.0 (72-115)	98.0 (72-122)	109.0 (90-167)	84.0 (23-110)
pH (units)	7.4 (6.7-8.1)	7.6 (6.9-8.4)	7.8 (7.2-8.8)	7.6 (6.9-7.9)
Conductance (µmhos at 25°C)	167.0 (90-356)	166.0 (99-302)	189.0 (106-310)	184.0(103-313)
Alkalinity (mg/L as $CaCO_4$)	74.4 (54.2-112.0)	71.8 (54.2-105.0)	--	--
Nitrate (µgN/L)	418.0 (110-810)	351.0 (110-820)	365.0 (100-680)	308.0 (100-560)
Nitrite (µgN/L)			25.0 (7-60)	22.0 (4-60)
Ammonia (µgN/L)	270.0 (40-900)	178.0 (50-730)	82.0 (30-130)	187.0 (50-350)
Orthophosphate (µgP/L)	146.0 (40-330)	138.0 (20-320)	125.0 (60-240)	152.0 (80-240)
Total Phosphorus (µgP/L)	257.0 (120-540)	231.0 (110-470)	213.0 (130-330)	--
Soluble N:P Ratio (x:l)	5.7 (1.8-16.6)	5.0 (1.6-13.0)	4.6 (1.8-12.2)	3.2 (1.9-4.9)
Chlorophyll *a* (mg/L)	6.4 (0.2-34.6)	6.7 (1.3-36.2)	5.6 (1.4-9.0)	--
Total Suspended Solids (mg/L)	13.3 (3.8-33.1)	13.2 (2.3-37.6)	--	--
Turbidity (FTU)	10.0 (2.8-32)	10.0 (2.6-38)	--	--
Total Coliforms (MPN/100 ml)	773.0 (70-2400)	345.0 (49-920) \	--	--
Total Coliforms (% 2,400)	11.0	0.0	--	--
Secchi Depth (m)			1.1 (0.6-1.5)	--

FTU = formazin turbidity unit.

E3.2.1.2 Klamath River between J.C. Boyle Reservoir and Copco No. 1 Reservoir

The City of Klamath Falls (1986, 1990) conducted water quality sampling at four mainstem sites and three tributary sites in the Klamath River between J.C. Boyle reservoir and Copco No. 1 reservoir during 1984-85 in conjunction with the Salt Caves Hydroelectric Project (proposed for construction near Stateline but never licensed or built). The mainstem sites included the Klamath River just downstream of J.C. Boyle dam at RM 226 (i.e., J.C. Boyle reservoir outflow), near the Frain Ranch area at RM 217.7, near the Oregon-California border at RM 209.8, and just above Copco reservoir at RM 203. The tributary sites included Rock Creek (RM 213.9), Shovel Creek (RM 206.5), and Long Prairie Creek (RM 203.3). Means and ranges of observed water quality parameters for these sites are provided in Tables E3.2-2 and E3.2-3.

Table E3.2-2. Mean and range (in parentheses) of observed values for water quality parameters, Salt Caves Project, Klamath River mainstem sites below J.C. Boyle dam, March 1984-February 1985.

Parameter (Units)	**Boyle Reservoir Outflow (RM 217.7)**	**Frain Ranch Site (RM 217.7)**	**Oregon-Calif. Border (RM 209.8)**	**Copco Reservoir Inflow (RM 203)**
Temperature (°C)	14.4 (4.0-23.0)	13.0 (2.0-24.0)	14.1 (5.2-19.8)	12.5 (1.7-19.7)
Dissolved Oxygen (mg/L)	8.8 (7.2-12.4)	9.3 (8.1-10.9)	9.0 (7.9-10.8)	9.2 (7.5-11.2)
Dissolved Oxygen (% saturation)	98.0 (72-122)	99 (74-135)	99.0 (72-120)	97.0 (74-120)
pH (units)	7.6 (6.9-8.4)	7.6 (7.0-8.8)	7.8 (7.3-8.8)	7.7 (7.1-8.7)
Conductance (μmhos at 25°C)	166.0 (99-302)	151.0 (103-264)	155.0 (116-252)	151.0 (117-258)
Alkalinity (mg/L as $CaCO_4$)	71.8 (54.2-105.0)	71.4 (48.2-98.2)	70.8 (55.0-97.4)	70.7 (53.5-95.9)
Total Hardness (mg/L as $CaCO_4$)		57.4 (41.4-82.2)	56.4 (39.5-79.5)	57.0 (39.7-78.8)
Nitrate (μgN/L)		381.0 (110-770)	316.0 (140-720)	.445.0 (100-940)
Ammonia (μgN/L)	178.0 (50-730)	168.0 (20-660)	91.0 (20-670)	123.0 (10-580)
Orthophosphate (μgP/L)	138.0 (20-320)	156.0 (60-900)	142.0 (40-900)	117.0 (60-220)
Total Phosphorus (μgP/L)	231.0 (110-470)	--	--	202.0 (120-350)
Soluble N:P Ratio (x:l)	5.0 (1.6-13.0)	5.0 (0.7-14.8)	4.6 (0.8-13.3)	5.4 (1.8-14.0)
Chlorophyll *a* (mg/L)	6.7 (1.3-36.2)	--	--	4.7 (0.5-21.2)
Total Dissolved Solids (mg/L)		134.0 (97-202)	128.0 (102-174)	131.0 (94-191)
Total Suspended Solids (mg/L)	13.2 (2.3-37.6)	12.1 (3.8-36.1)	13.0 (5.3-28.4)	10.9 (1.6-26.9)
Turbidity (FTU)	10.0 (2.6-38)	9.4 (2.3-31)	9.5 (3.1-33)	9.4 (2.1-30)
Total Coliforms (MPN/100 ml)	345.0 (49-920) \	326.0 (49-1600)	379.0 (49-920)	371.0 (23-1600)
Total Coliforms (% 2400)	0.0	0.0	0.0	0.0
Volatile Solids (mg/L)		--	--	140.0 (113-157)

Source: City of Klamath Falls, 1986.

Table E3.2-3. Mean and range (in parentheses) of observed values for water quality parameters, Salt Caves Project, Klamath River tributary sites below J.C. Boyle dam, March 1984-February 1985.

Parameter (Units)	Rock Creek (RM 213.9)	Shovel Creek (RM 206.5)	Long Prairie Creek (RM 203.3)
Temperature (°C)	12.9 (7.1-21.6)	9.4 (2.9-17.0)	10.7 (4.9-15.0)
Dissolved Oxygen (mg/L)	9.0 (8.0-10.8)	9.6 (8.1-11.7)	9.5 (7.8-11.8)
Dissolved Oxygen (% saturation)	97.0 (78-108)	94.0 (77-114)	96.0 (83-125)
pH (units)	7.9 (7.6-8.1)	7.6 (7.0-8.3)	7.6 (6.88.0)
Conductance (μmhos at 25°C)	165.0 (137-227)	82.0 (50-107)	136.0 (79-207)
Alkalinity (mg/L as $CaCO_4$)	103.2 (76-126)	53.0 (34-67)	84.7 (45-108)
Total Hardness (mg/L as $CaCO_4$)	186.0 (100-460)	110.0 (100-200)	208.0 (100-420)
Nitrate (μgN/L)	--	--	--
Ammonia (μgN/L)	--	--	--
Orthophosphate (μgP/L)	26.0 (10-40)	49.0 (20-80)	40.0 (20-210)
Total Phosphorus (μgP/L)	--	--	--
Soluble N:P Ratio (x:l)	8.9 (2.5-23.0)	2.6 (1.3-6.0)	8.0 (1.3-21.0)
Chlorophyll *a* (mg/L)	--	--	--
Total Dissolved Solids (mg/L)	9.1 (3.5-23.0)	3.3 (1.0-8.5)	5.5 (1.2-28.5)
Total Suspended Solids (mg/L)	8.8 (3.2-18)	4.6 (1.7-8.0)	8.2 (2.0-27.0)
Turbidity (FTU)	8.8 (3.2-18)	4.6 (1.7-8.0)	8.2 (2.0-27.0)
Total Coliforms (MPN/100 ml)	950.0 (350-2400)	363.0 (49-1600)	548.0 (170-920)
Total Coliforms (% 2400)	20.0	0.0	0.0
Volatile Solids (mg/L)	--	--	--

Source: City of Klamath Falls, 1986.

The City of Klamath Falls (1986) reported that in general the water temperatures in the Klamath River in the study area responded to climatological changes. Peak water temperatures were recorded in mid-July through early August, and annual minimum water temperatures were recorded in December and January, concurrent with the annual peaks and minimums in regional air temperatures recorded at Klamath Falls. The maximum mean daily water temperature in the Klamath River recorded by thermographs deployed for the Salt Caves Project studies was 22.3°C (72.1°F) on July 19, 1984, at the site upstream of J.C. Boyle reservoir. The maximum instantaneous water temperature was 25.8°C (78.4°F) measured in the surface waters of J.C. Boyle reservoir on July 15, 1984. The minimum mean daily water temperature recorded by thermographs deployed for the Salt Caves Project studies during 1984 was 1.0°C (33.8°F) on several dates in December in the Klamath River upstream of J.C. Boyle reservoir.

The City of Klamath Falls (1986) reported significant diel fluctuations in water temperatures in the river between J.C. Boyle dam and Copco reservoir. The greatest diel fluctuations in water temperatures occurred from late June to early September as a result of a combination of factors, including daytime solar warming, midday peaking operations at the J.C. Boyle facility, and the substantial accretion (about 250 cfs) of cool groundwater inflow directly to the river channel between the J.C. Boyle dam and powerhouse. By comparison, relatively little diel fluctuation in water temperatures occurred during other sampling periods (e.g., spring and fall). During these times, rather continuous J.C. Boyle reservoir release (e.g., turbine operation and diversion structure spill) maintained consistent downstream river discharges.

The levels of dissolved oxygen within the Klamath River between J.C. Boyle dam and Copco reservoir, as measured during the 1984-85 Salt Caves Project studies, ranged from 7.2 to 12.4 mg/L and 72 to 122 percent saturation (City of Klamath Falls, 1986). However, these data consisted of discrete measurements taken during midday, and so were likely representative of near-maximum conditions. Dissolved oxygen concentrations measured in the tributaries ranged from 7.8 to 11.8 mg/L and 77 to 125 percent saturation.

On a seasonal basis, dissolved oxygen concentrations generally varied inversely with water temperature, e.g., higher water temperatures were associated with lower dissolved oxygen concentrations (City of Klamath Falls, 1986). This phenomenon is common in freshwater, since dissolved oxygen saturation occurs at lower concentration as temperature increases. However, during late summer and early fall, dissolved oxygen concentrations of less than 100 percent saturation occurred.

The City of Klamath Falls (1986) reported that values of pH within the Klamath River from J.C. Boyle dam to Copco reservoir in 1984-85 ranged from 6.9 to 8.8 (see Table E3.2-2). Values did not follow a distinct seasonal trend during the period sampled; however, peak pH values in excess of 8.0 were generally recorded during midsummer at most sites and were attributed in part to increases in algal primary productivity. Increases in phytoplankton productivity throughout summer and early fall raised pH by removing carbon dioxide from the water during photosynthesis.

The City of Klamath Falls (1986) reported that concentrations of total suspended solids and turbidity observed in the Klamath River during the 1984-85 Salt Caves Project studies varied widely from season to season. However, concentrations within a given season were similar from site to site. Both total suspended solids and turbidity were highest during spring, declined to minimum levels at midsummer, and increased again in the fall. Maximum values of total suspended solids were on the order of 25 to 40 mg/L, and maximum levels of turbidity were on the order of 30 to 40 formazin turbidity units (FTU). Values for suspended solids and turbidity were generally below 10 mg/L and 5 FTU, respectively, throughout the summer. The occurrence of peaks in suspended solids and turbidities generally corresponded with periods of relatively high stream discharge. The City of Klamath Falls (1986) inferred that the high levels of suspended solids and turbidity measured in the Klamath River at such times were a result of seasonal surges in runoff.

Turbidity and total suspended solids values observed at tributary sites during the 1984-85 Salt Caves Project studies were generally similar to those observed at the Klamath River sites (City of Klamath Falls, 1986). However, levels of both constituents were particularly high in Long Prairie Creek and Rock Creek when sampling began in March 1984. The City of Klamath Falls (1986) inferred that pumping of turbid Meiss Lake waters probably contributed to elevated values in Rock Creek, since pumping from Meiss Lake to the Klamath River via Rock Creek occurred until the end of March. The City of Klamath Falls (1986) indicated that no perceptible increase was observed in the Klamath River as a result of these turbid tributary inflows, since both discharge and ambient turbidity values in the river itself were relatively high at the time.

Specific conductance and total dissolved solids (TDS) concentrations in the Klamath River measured during 1984-85 indicated a relatively wide seasonal variation in total ionic activity and concentrations (City of Klamath Falls, 1986). For example, at the Klamath River mainstem sampling sites, specific conductance values ranged from 90 to 356 µmhos, while TDS values ranged from 99 to 284 mg/L. The higher conductance and TDS values occurred at all sites during summer and early autumn. The City of Klamath Falls (1986) attributed these higher values to increased contributions of regional agricultural return flows combined with seasonal low Klamath River discharge.

This same seasonal trend was also evident for total hardness and alkalinity values measured during 1984-85 (City of Klamath Falls, 1986). On the basis of the observed total hardness concentrations, the City of Klamath Falls concluded that Klamath River waters could be classified as ranging from soft (less than 75 mg/L as $CaCO_3$) during the spring to moderately hard (75 to 150 mg/L as $CaCO_3$) during summer. Alkalinity values indicated a wide range in buffering capacity, with greatest buffering potential occurring during the summer period when waters were chemically most concentrated and algal photosynthetic activity was greatest.

The macronutrients phosphorus and nitrogen also exhibited distinct seasonal changes in concentrations measured during 1984-85 (City of Klamath Falls, 1986). Concentrations of orthophosphate, nitrate, and ammonia were found to be in excess of those that promote down-stream enrichment and eutrophication (City of Klamath Falls, 1986, based on Welch, 1980). Concentrations of soluble orthophosphorus were highest during the summer months. Soluble nitrate concentrations exhibited a seasonal pattern similar to orthophosphorus during the summer; however, unlike orthophosphorus, nitrate concentrations increased sharply again during the winter. The seasonal trends in ammonia concentrations differed from those observed for nitrates and orthophosphorus; i.e., concentrations were instead low throughout spring and summer, and high during the fall and winter.

The City of Klamath Falls (1986) concluded that the summer peak in orthophosphorus and nitrate concentrations was most likely due to the relatively high proportion of high-nutrient irrigation return flows that entered the Klamath River during the seasonal low flow period. The city also concluded that the rapid rise in concentrations of orthophosphorus and nitrate observed in the fall and winter was probably largely due to peak discharge to the river of agricultural and marshland drainages (e.g., Klamath Straits Drain). The City of Klamath Falls (1986) further concluded that, since ammonia is the molecular form in which nitrogen is most readily taken up and utilized by vegetation, its low concentration during the summer may have been due to both terrestrial and aquatic plant uptake. The rapid rise in ammonia concentrations during the winter may then have been related to winter dieback of vegetation and lack of plant uptake, coupled with decomposition and leaching of organic nitrogen compounds.

E3.2.1.3 Copco and Iron Gate Reservoirs

The City of Klamath Falls (1986) reported that, among the three Project reservoirs, the degree of thermal stratification was greatest and the period of stratification longest in Iron Gate reservoir.

Conversely, J.C. Boyle reservoir was sufficiently short that stratification typically did not occur, except for brief periods in summer when peaking operations and resultant reservoir releases were temporarily halted for annual maintenance purposes. Copco reservoir was generally median between Iron Gate and J.C. Boyle reservoirs with regard to both degree and period of stratification. The City of Klamath Falls (1986, 1990) explained the differences among the three impoundments relating to stratification by inherent differences in reservoir physical characteristics (i.e., Iron Gate reservoir contains the greatest volume, J.C. Boyle the smallest, and Copco an intermediate volume).

The City of Klamath Falls (1986) reported that vertical profiles of dissolved oxygen in Copco and Iron Gate reservoirs generally reflected the degree and duration of concurrent thermal stratification in each reservoir. During sampling in 1985, dissolved oxygen concentrations of less than 1 mg/L in the bottom waters of Copco reservoir were measured from the initial sampling on August 14 until September 24 (City of Klamath, Falls 1986). Simultaneous surface concentrations varied from 6.8 to 11.5 mg/L and 76 to 145 percent saturation over the same period. Thermal stratification subsided during September, causing partial re-oxygenation of the bottom waters; completely mixed conditions were observed on and after the sampling on October 10 (City of Klamath Falls, 1986). Surface waters were supersaturated with oxygen (greater than 100 percent saturation) on both sampling dates in August. From September to November, however, surface waters varied from only 58 to 88 percent saturation. Sampling conducted in Copco reservoir during both the later afternoon and early morning hours of August 14-15, 1985, revealed little, if any, diel variation in dissolved oxygen saturation, even in the highly productive, supersaturated surface waters (City of Klamath Falls, 1986).

The City of Klamath Falls (1986) observed anoxic bottom waters in Iron Gate reservoir from the initial sampling on September 17 through October 24. During this same period, surface water dissolved oxygen concentrations varied from only 4.7 to 6.5 mg/L and 49 to 76 percent saturation. Uniform, but subsaturated, dissolved oxygen conditions were prevalent throughout Iron Gate reservoir on the subsequent and final sampling of November 14.

Fortune et a1. (1966), the U.S. Environmental Protection Agency (EPA, 1978), and Pacific Power & Light (PPL, now PacifiCorp)(1984) previously reported both anoxic bottom waters and fully saturated surface waters in Iron Gate reservoir under conditions of thermal stratification throughout the summer and early fall of several study years in the 1960s and 1970s. PacifiCorp (1992) also measured similar thermal and oxygen stratification during samplings conducted in July and October 1992.

The City of Klamath Falls (1986) reported that no large vertical gradient in pH was measured in Copco reservoir during the sampling of August through November 1985. The maximum pH recorded was 8.2 at the surface on September 24. The minimum record was 6.2 near the bottom on October 2. During thermally stratified periods, the pH of Copco reservoir surface waters was consistently greater than that of the bottom waters, but the pH differential never exceeded 1 pH unit. The highest values (7.9 to 8.2) were measured in the surface waters in September. These pH data were generally recorded during midday, when algal productivity and, hence, pH are typically at or near daily maximum levels. However, sampling conducted during both afternoon and early morning hours of August 14-15, 1985, revealed only minor, if any, diel variation in pH, even in highly productive surface waters.

The pH values measured in Iron Gate reservoir during August through November 1985 were similar to those measured in Copco reservoir (City of Klamath Falls, 1986). Maximum vertical pH gradients of approximately 1.4 pH units were recorded. The City of Klamath Falls (1986) concluded that these gradients were a result of increases in surface water pH (caused by higher phytoplankton productivity at the surface), since values of pH in deeper water (i.e., throughout the hypolimnion) remained constant.

During 1984-85, the City of Klamath Falls (1986) measured little or no differences in total ortho-phosphorus concentrations between the inflows and outflows of Copco and Iron Gate reservoirs. Nitrate concentrations occasionally tended to be lower and ammonia concentrations higher at outflows from Copco and Iron Gate reservoirs in comparison to inflows.

The City of Klamath Falls (1986) also reported that biochemical oxygen demand (BOD), an indirect measure of the amount of organic material in water, tended to decrease as Klamath River water passed through both Copco and Iron Gate reservoirs. Below Iron Gate reservoir, BOD of Klamath River water was only about one-third that above Copco reservoir, thus indicating that significant settling and biological metabolism of organic material occurred in the reservoirs.

The ratios of soluble nitrogen to phosphorus concentrations (N:P) in Copco and Iron Gate reservoirs were typically below six at all sampling stations during the summers of 1984 and 1985 (City of Klamath Falls, 1986). The N:P ratio increased during the fall and winter of both years, with maximum ratios ranging from 10 to 28. Based on these ratios, the City of Klamath Falls (1986) concluded that nitrogen was the nutrient that most frequently limits growth of reservoir phytoplankton, and that this nitrogen limitation explained the dominance of the blue-green algae, such as *Aphanizonmenon*, during summertime algae blooms.

E3.2.1.4 Klamath River Downstream from Iron Gate Dam

Water quality in the Klamath River downstream from Iron Gate dam has also been studied in some detail. Water quality data for the Klamath River downstream from Iron Gate dam have been previously collected by USGS, California Department of Water Resources (CDWR), and North Coast Regional Water Quality Control Board. The national STORET database includes water quality data for the Klamath River below Iron Gate dam, collected periodically over several years. In addition, an extensive record of daily maximum-minimum water temperature data are available for USGS gauging stations on the Klamath River downstream of Iron Gate dam (No. 11516530) and near Seiad Valley, California (No. 11520500).

The University of California at Davis (Deas and Orlob, 1999; Deas, 2000) conducted a comprehensive study of instream flow and water quality requirements for maintenance of anadromous fish habitat in the Klamath River downstream from Iron Gate dam. Iron Gate reservoir and the Klamath River from Iron Gate dam (RM 190) to the USGS gauge (RM 129) near Seiad Valley were modeled for flow and water quality. Iron Gate reservoir was represented as a one-dimensional, vertically stratified system using the Water Quality for River-Reservoir Systems (WQRRS) model. The river was modeled for flow and water quality using the finite element models RMA-2 and RMA-11, respectively. The river and reservoir models were calibrated and verified over the 1996 and 1997 field seasons, respectively. The project was funded through the Klamath River Basin Fisheries Task Force (Project No. 96HP01) and administered by USFWS.

USGS (Campbell, 1999), in collaboration with PacifiCorp, USBR, and North Coast Regional Water Quality Control Board, conducted a water quality study in the mainstem Klamath River in 1996 and 1997. The study included sites from Iron Gate dam to Seiad Valley that were monitored using multiparameter recorders. Water quality sampling was also performed at monthly intervals at these locations. Using this information, USGS (Hanna and Campbell, 2000) developed a System Impact Assessment Model for resource management on the Klamath River. SIAM is an integrated set of computer models that quantify selected relationships among physical, chemical, and biological variables and stream flow in a river. SIAM was developed for the Klamath River from Upper Klamath Lake to Seiad Valley, California. The modeling components for SIAM currently consist of a water quantity model (MODSIM, developed by Colorado State University), a water quantity model (HEC5Q, developed by the U.S. Army Corps of Engineers), a fish production model (SALMOD, developed by USFWS), and various measures of aquatic habitat. The use of SIAM is intended to further the process of reaching a decisive consensus on water management within the basin and to improve anadromous fish restoration.

PacifiCorp (1998) conducted spot sampling of total dissolved gas (TDG) during the summer months of 1994-1996 downstream of each of the Project facilities. Values ranged from 95 to 115 percent. TDG measurements exceeded 110 percent in waters greater than 2 feet in depth on one occasion at the West Side facility and on two occasions at Iron Gate dam. These occasions occurred in the summer of 1994 during low-flow drought conditions (500 cfs). These high TDG values were probably the result of large amounts of air mixed with water in the turbines to prevent cavitation when the powerhouse was operating at flows below turbine efficiency.

E3.2.2 Analysis of Previous Water Quality Data

PacifiCorp compiled relevant water quality data and information for the Project into a computerized database. Plots and statistical analyses were performed to assess historical trends, both temporal and spatial. The Water Resources FTR provides additional details on the purpose, methods, and results of the compilation and review of previous water quality data. The water quality database is available on PacifiCorp's relicensing website: http://newwww.pacificorp.com/Article/Article579.html.

Data were assembled from EPA's STORET database, ODEQ's LASAR database, USGS National Information System (NIS) database, Klamath Resource Information System (KRIS) records, USBR, and data submitted by other government and tribal resource agencies. The compiled database includes data from USEPA Headquarters, EPA Region 9, EPA Region 10, U.S. Forest Service, OWRD, USBR, ODEQ, California Water Resources Control Board, USGS, City of Klamath Falls, and BLM. The database contains 57,378 records with measurements for 66 distinct constituents from 175 sites sampled on 2,180 different dates between October 12, 1950, and June 20, 2001. Figure E3.2-1 is a map showing water quality sampling sites identified in the Klamath River basin.

Each sample location was given a unique identification code consisting of a two-letter designation for the water body (e.g., KR for Klamath River) and a five-digit designation for the river mile based on the PacifiCorp geographical information system (GIS) coverage for the Klamath River. River mile zero is at the mouth of the Klamath River. Thus, site KR23490 is on the Klamath River at RM 234.90 (at the Highway 66 bridge near Keno, Oregon).

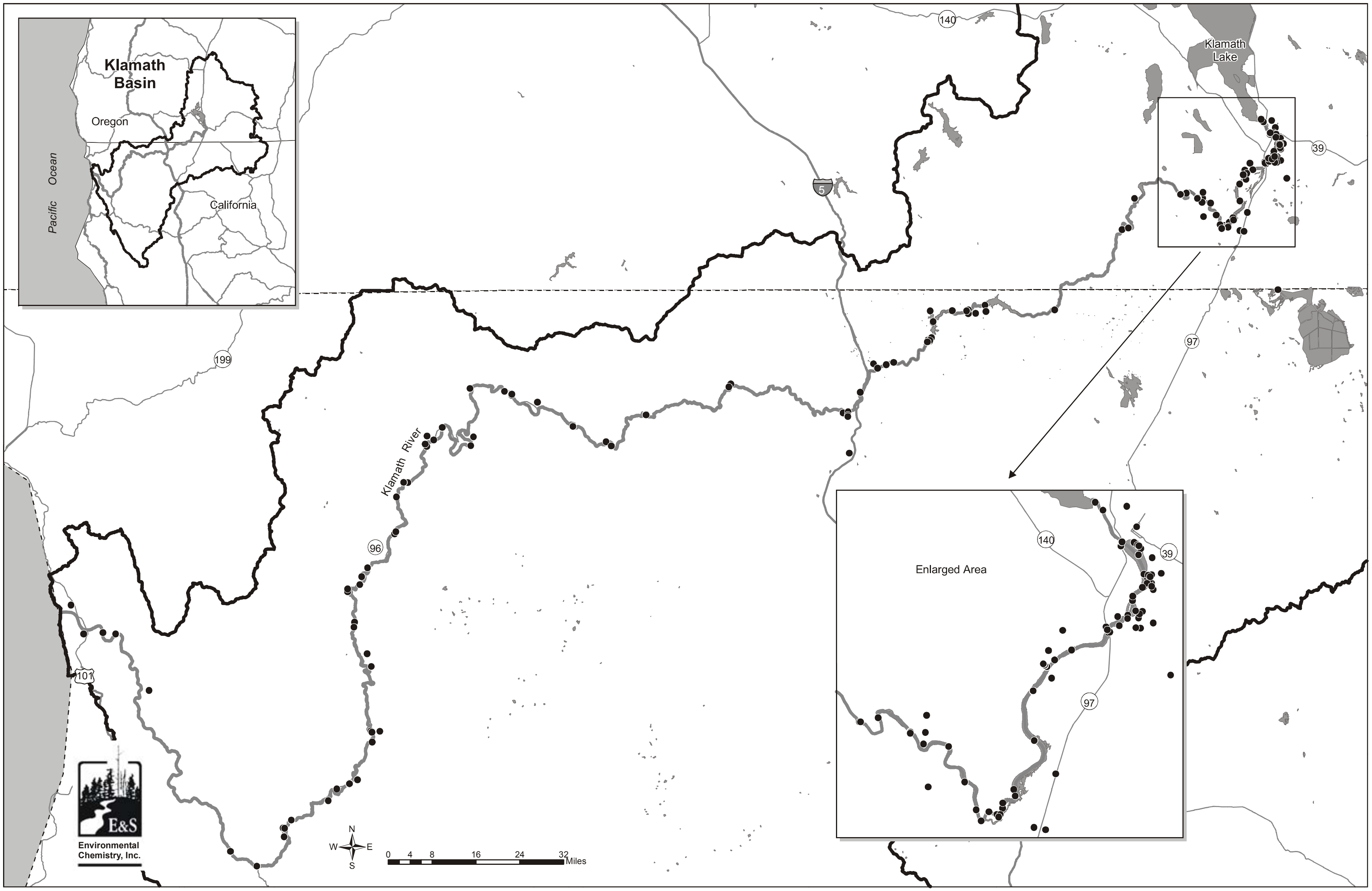


Figure E3.2-1. Distribution of water quality sampling sites identified in the Klamath River basin from 1950-2001.

Not all sites were sampled equally. Of the 175 sites, only 87 were sampled more than five times during the 50-year period of record. Nor were all constituents measured with equal frequency. The most frequently sampled sites are listed in Table E3.2-4. Ten of the 66 constituents account for more than 85 percent of the 57,378 measurements included in the database. The most frequently measured constituents are listed in Table E3.2-5. The complete list of constituents and analysis of the data is available in the Water Resources FTR, Section 2.0 (and associated appendices).

The number of samples collected in the basin varied through time. Figure E3.2-2 shows the year-to-year variation in the number of samples collected from the Klamath basin sites between 1950 and 2001.

Table E3.2-4. The most frequently sampled sites in the Klamath River basin between 1950 and 2001.

Rank	Site ID	Site Name	Number of Days Sampled
1	KR00579	Klamath River at Klamath Glen	514
2	KR05912	Klamath River at Orleans	408
3	KR12855	Klamath River near Seiad Valley	349
4	KR18952	Klamath River below Iron Gate dam	338
5	KR23490	Klamath River at Keno Bridge (Hwy. 66)	321
6	SH00	Shasta River near Yreka	304
7	KR14906	Klamath River above Hamburg reservoir site	264
8	KS01	Klamath Straits Drain at Pumping Plant F	253
9	KR23193	Klamath River near Keno	245
10	KR24898	Klamath River at Hwy. 97 bridge	239
11	KR25312	Link River at mouth	234
12	KR23503	Klamath River below J.C. Boyle powerhouse	233
13	SA00	Salmon River at Somes Bar	149
14	KR00822	Klamath River near Klamath	146
15	KR19621	Klamath River below Fall Creek near Copco*	110
16	KR14900	Klamath River near Hamburg	92
17	KR06593	Klamath River below Salmon River	91
18	KR18334	Klamath River near Henley	82
19	KR25479	Link River at Fremont St. bridge	65
20	KR25344	Link River (421404121480101)	43
21	KR20642	Klamath River upstream of Shovel Creek	37
22	KR19645	Copco dam outflow	36
23	KR18973	Iron Gate dam outflow	36
24	KR17607	Klamath River downstream of Shasta River	35
25	KR18238	Klamath River upstream of Cottonwood Creek	35

*All samples from this site were collected prior to the construction of Iron Gate dam.

Table E3.2-5. Most frequently measured constituents in the Klamath River basin, 1950-2001.

Rank	Code	Constituent Name	Total Analyses
1	pH	pH	7,985
2	DOPER	Dissolved oxygen percent saturation	7,336
3	DOCON	Dissolved oxygen concentration	7,249
4	SPC	Specific conductance	7,155
5	ALKT	Alkalinity, total	3,044
6	NO_3D	Nitrate nitrogen, dissolved	2,670
7	PT	Phosphorus, total	2,553
8	TURB	Turbidity	2,525
9	PO_4	Orthophosphate, dissolved	2,281
10	TKN	Total Kjeldahl nitrogen	2,084
11	NH_3T	Ammonia nitrogen, total	1,857
12	TEMP	Temperature, water	1,296
13	BOD	Biochemical oxygen demand	1,247
14	NO_3T	Nitrate nitrogen, total	1,166
15	Fecal	Fecal coliform	889
16	CHLA	Chlorophyll *a*	655
17	ALKF	Alkalinity, Field	599
18	TOC	Total organic carbon	488
19	Cu_Dis	Copper, dissolved	274
20	Pb_Dis	Lead, dissolved	274
21	As_Dis	Arsenic, dissolved	272
22	Zn_Dis	Zinc, dissolved	244
23	TDS	Total dissolved solids	241
24	NH_3	Ammonia nitrogen	237
25	NH_3D	Ammonia nitrogen, dissolved	219

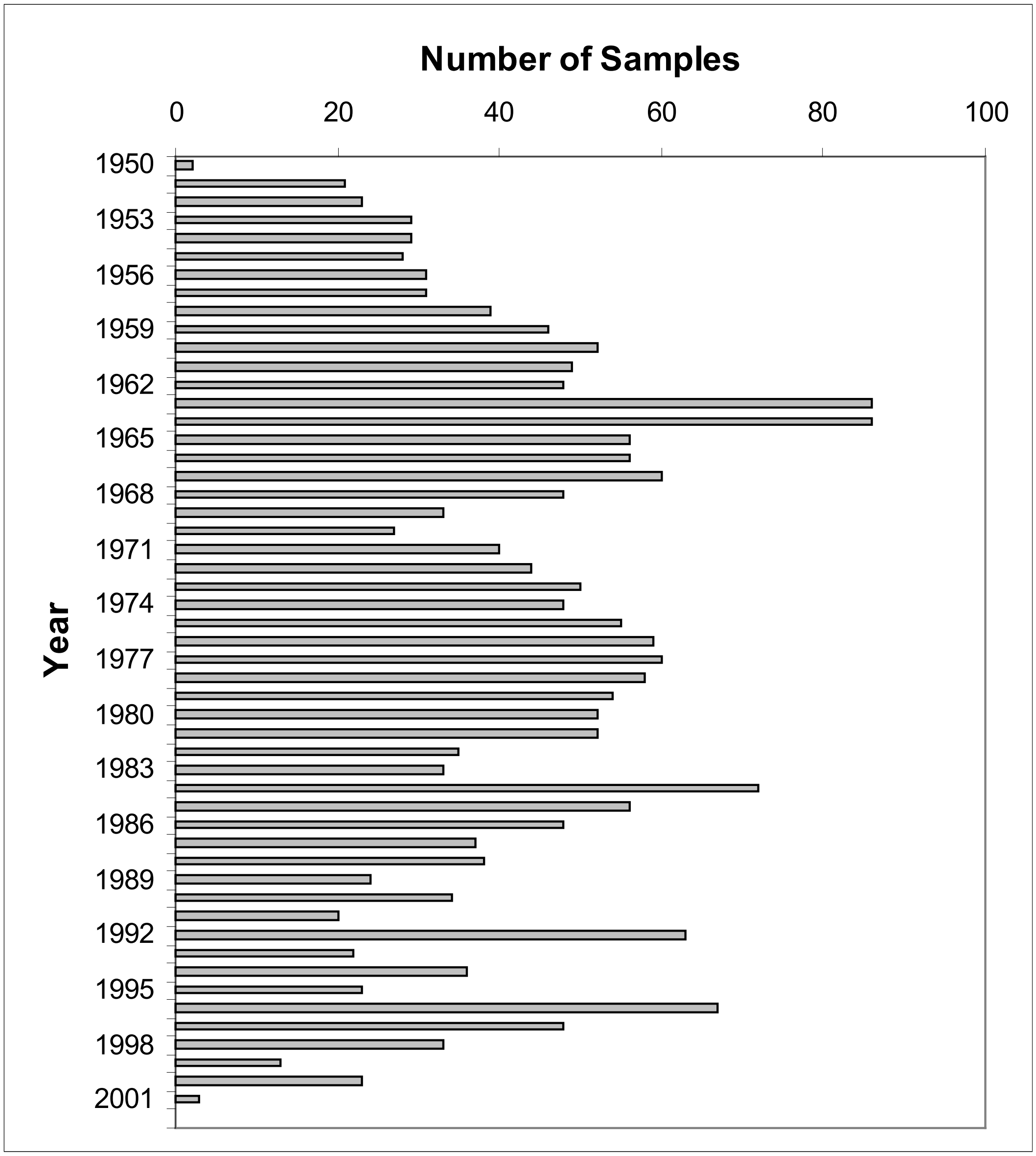


Figure E3.2-2. The number of water quality samples collected in the Klamath River basin below Upper Klamath Lake, 1950-2001.

E3.2.2.1 Spatial Trends in the Previous Data

The historical data provide the opportunity to compare water quality among sites along the Klamath River. However, not all sites had sufficient data to make adequate comparisons. Likewise, not all constituents were measured frequently enough at the most sampled sites to provide sufficient data for comparison. Those sites with sufficient data to be used in this analysis are listed in Table E3.2-6. The constituents with enough data for comparison were specific conductance, alkalinity, dissolved oxygen, pH, nitrate nitrogen, ammonia nitrogen, BOD, total Kjeldahl nitrogen (TKN), total phosphorus, orthophosphate phosphorus, turbidity, and chlorophyll *a*. These sites and constituents cover most of the river and most of the constituents of water quality concern. Because each site differs in the number of analyses and the dates of sample collection, detailed interpretation of the differences between the sites is probably not warranted. Nevertheless, the pattern of differences can provide some insight into the dynamics of water quality in the Klamath River.

Spatial trends in the data have been identified through nonparametric graphical analysis primarily using scatterplots. Summary statistics and detailed graphical analysis for each constituent are provided in the Water Resources FTR, Section 2.0 and Appendix 2C.

Table E3.2-6. Frequently sampled sites in the Klamath River basin used for site comparisons.

RM	Site ID	Location
5	KR00579	Klamath River at Klamath Glen
8	KR00822	Klamath River south of Hoopa
59	KR05912	Klamath River at Orleans
65	KR06593	Klamath River below Salmon River
128	KR12855	Klamath River near Seiad Valley
142	KR14260	Klamath River downstream of Scott River
149	KR14900	Klamath River at Klamath River School near Hamburg
160	KR16075	Klamath River downstream of Beaver Creek
176	KR17607	Klamath River downstream of Shasta River
179	KR17923	Klamath River at Collier rest stop
182	KR18238	Klamath River upstream of Cottonwood Creek
183	KR18334	Klamath River near Henley
184	KR18417	Klamath River at Klamathon Bridge
189.5	KR18952	Klamath River below Iron Gate dam
189.7	KR18973	Iron Gate dam outflow
191	KR19000	Iron Gate reservoir
192	KR19198	Iron Gate reservoir
196[1]	KR19621	Klamath River below Fall Creek (pre-dam)
197	KR19645	Copco dam outflow
198	KR19856	Klamath River 0611A2 (below Copco No. 1 dam)
199	KR19874	Copco reservoir
203	KR20300	Copco inflow (Angler access 2 above Copco reservoir)
206	KR20642	Klamath River upstream of Shovel Creek
209	KR20932	Klamath River near Stateline
217	KR21700	Salt Caves site

Table E3.2-6. Frequently sampled sites in the Klamath River basin used for site comparisons.

RM	Site ID	Location
221	KR22127	Klamath River below J.C. Boyle power plant near Keno
222	KR22200	Canyon – C. (Klamath River in J.C. Boyle bypass reach)
224	KR22400	Below J.C. Boyle dam
225	KR22505	J.C. Boyle reservoir at deepest point
228	KR22822	Klamath River above J.C. Boyle reservoir
231	KR23193	Klamath River near Keno
232	KR23200	Klamath River downstream of Keno dam
234	KR23490	Klamath River at Keno bridge (Hwy. 66)
235	KR23503	Klamath River below Big Bend power plant
236	KR23656	Klamath River at irrigation pumphouse
238	KR23828	Klamath River directly south of Hill 4315 (downstream of Klamath Straits Drain)
239	KR23932	Klamath River at powerline crossing (downstream of Klamath Straits Drain)
240	KR24013	Klamath River 1,000 feet downstream of Klamath Straits Drain
240.5[2]	KS01	Klamath Strait 200 feet downstream of Pumping Plant F (South channel)
241	KR24077	Klamath River 1,000 feet upstream of Klamath Straits Drain
244	KR24408	Klamath River downstream of North canal (Midland)
245	KR24589	Klamath River at Miller Island boat ramp
247	KR24713	Klamath River at Weyerhaeuser Mill smokestack
248	KR24894	Klamath River at Hwy. 97 bridge, southeast
249	KR24901	Klamath River at Hwy. 97 bridge, northeast
250	KR25015	Klamath River at north end of Dog Pound Island
251	KR25127	Klamath River at KLAD radio tower
252	KR25200	Lake Ewauna between sewage treatment plants
253	KR25312	421404121480101 (Link River)
254	KR25479	Link River at Fremont St. bridge

[1] Site flooded by Iron Gate reservoir.

[2] Approximate river mile of confluence.

Specific Conductance

Specific conductance is an indirect measure of the amount of dissolved solids in the water. Changes in specific conductance in a river can indicate a source of pollution (increase) or perhaps inputs from tributaries or groundwater (decrease or increase). The median values for specific conductance for the period of record at selected sites are shown in Figure E3.2-3.

The Klamath Straits Drain (RM 240.5) stands out because its specific conductance is much higher than other sites along the river. The median specific conductance of water entering Lake Ewauna (RM 253) is lower than the sites downstream. The influence of Klamath Straits Drain can be seen in the increase in median specific conductance in sites immediately downstream. The influence of springs below J.C. Boyle dam is reflected in lower specific conductance below RM 225. Specific conductance slightly increases in the Klamath River between the Shasta River (RM 176) and Seiad Valley (RM 128), and is somewhat lower nearer the mouth downstream of the Salmon River (RM 65). This may reflect the influence of tributary streams.

Alkalinity is a measure of the acid-neutralizing capacity of the water. It is also influenced by the amount of dissolved material in the water, and thus shows a pattern similar to specific conductance. Alkalinity is relatively low in Link River (RM 253) and increases in Lake Ewauna to a relatively constant value from Keno dam (RM 232) to below Iron Gate dam (RM 189). Sites near Hamburg (RM 149) and Seiad Valley (RM 128) have higher alkalinity, possibly a result of input from the Shasta River (Figure E3.2-3).

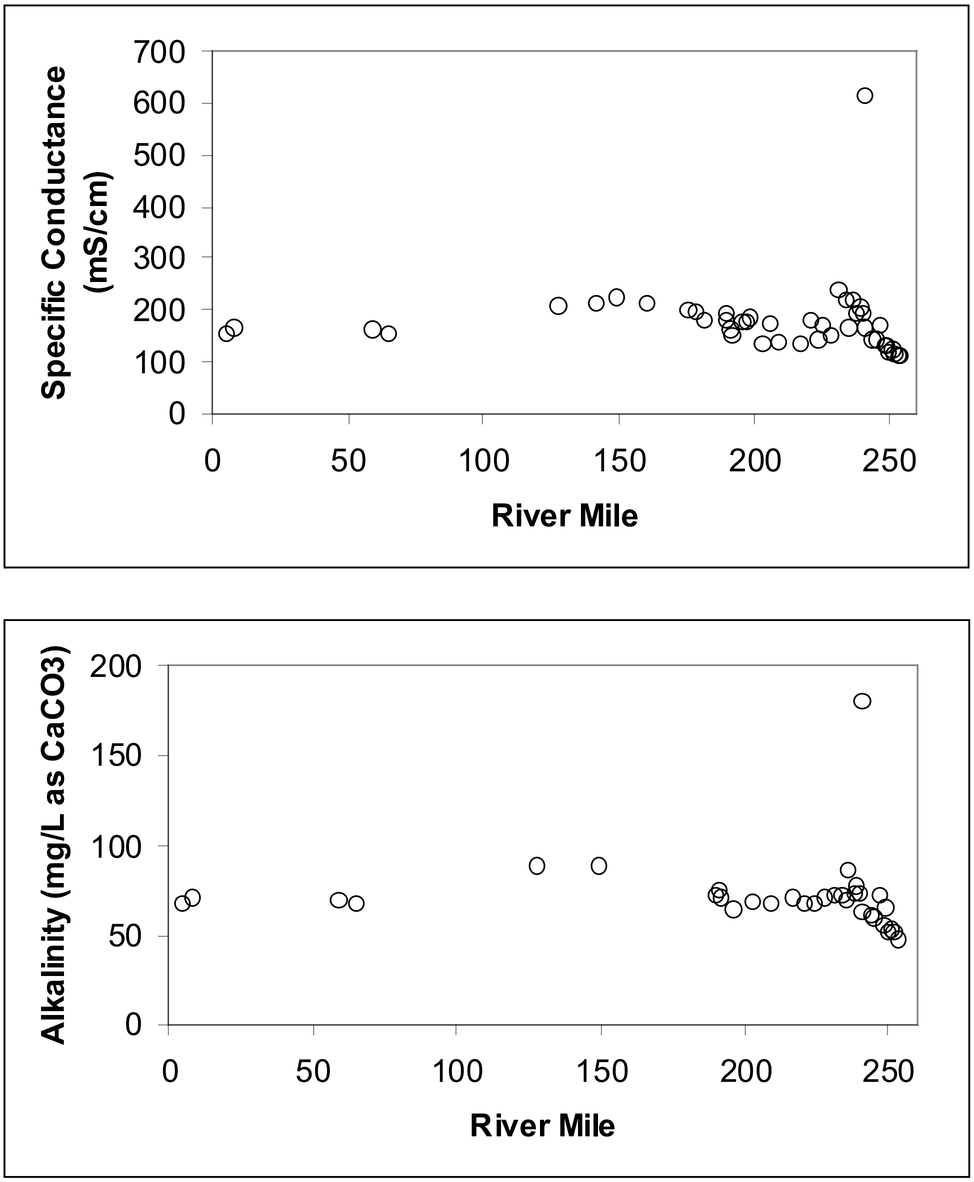


Figure E3.2-3. Median values for specific conductance (µS/cm) and alkalinity (mg/L as $CaCO_3$) measured at various sites in the Klamath River between 1950 and 2001.

Dissolved Oxygen

Dissolved oxygen, unlike specific conductance, is not a conservative constituent, but rather is influenced by local conditions of elevation and temperature. Photosynthesis by plants can increase dissolved oxygen, while respiration by bacteria, plants, and other organisms can decrease dissolved oxygen. For the elevations and temperatures encountered in the Klamath River, the saturation concentration of dissolved oxygen range between approximately 8 and 10.5 mg/L. As shown in Figure E3.2-4, median dissolved oxygen measured at many sites along the Klamath River generally fell in this range.

As is evident in Figure E3.2-4, however, a number of locations exhibit relatively low median dissolved oxygen. These sites are clustered in two areas. One, between RM 252 and RM 224, reflects the anoxic conditions that often exist in Lake Ewauna (Keno reservoir) during periods of the summer. The second, between RM 199 and RM 189, reflects measurements taken from the hypolimnion of Copco and Iron Gate reservoirs during stratification. Although median values of measurements collected over several years in different seasons and at different times of day cannot adequately describe the dissolved oxygen conditions at any particular site, the data assembled here suggest that dissolved oxygen is near saturation values in those regions of the Klamath River that are free-flowing.

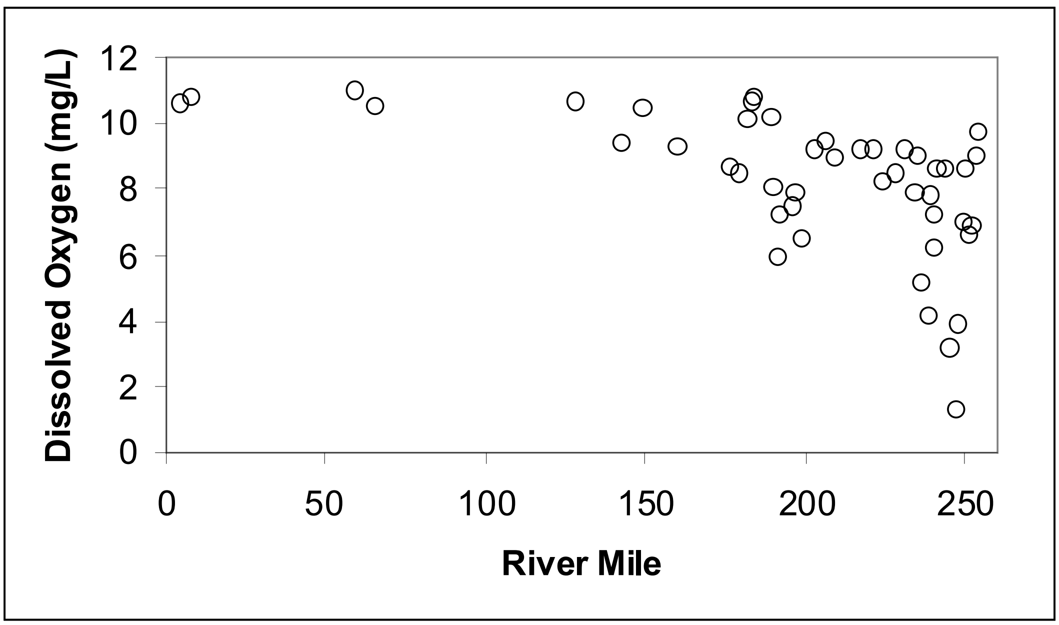


Figure E3.2-4. Median values for dissolved oxygen (mg/L) measured at various sites in the Klamath River between 1950 and 2001.

Nutrients

Nitrogen and phosphorus are important as major nutrients required by algae in the river system. Inputs of nutrients can lead to excessive algal growth, which in turn can have adverse water quality consequences, such as high pH and large diurnal swings in dissolved oxygen concentrations. The available historical data for nitrogen in the Klamath River show relatively low ammonia concentrations in Link River, but higher concentrations in Upper Klamath Lake, Lake Ewauna, and Keno reservoir. Median ammonia concentration is relatively low below Iron Gate dam (Figure E3.2-5). The historical nitrate data indicate that nitrate concentrations were relatively low in the Klamath River above Iron Gate dam, but higher in the lower reaches of the river (Figure E3.2-6).

The historical data for nitrate illustrate some of the difficulties encountered in interpreting historical data. Several high median values occur between RM 196 and RM 228. Inspection of the data reveal that all these data are from a single study (with the exception of RM 196, a pre-dam site below the mouth of Fall Creek) and are higher than median values of other sites in that river reach based on data from other sources. From the information available, it is not possible to determine whether the single-study data represent a real difference in river conditions or reflect a methodological difference.

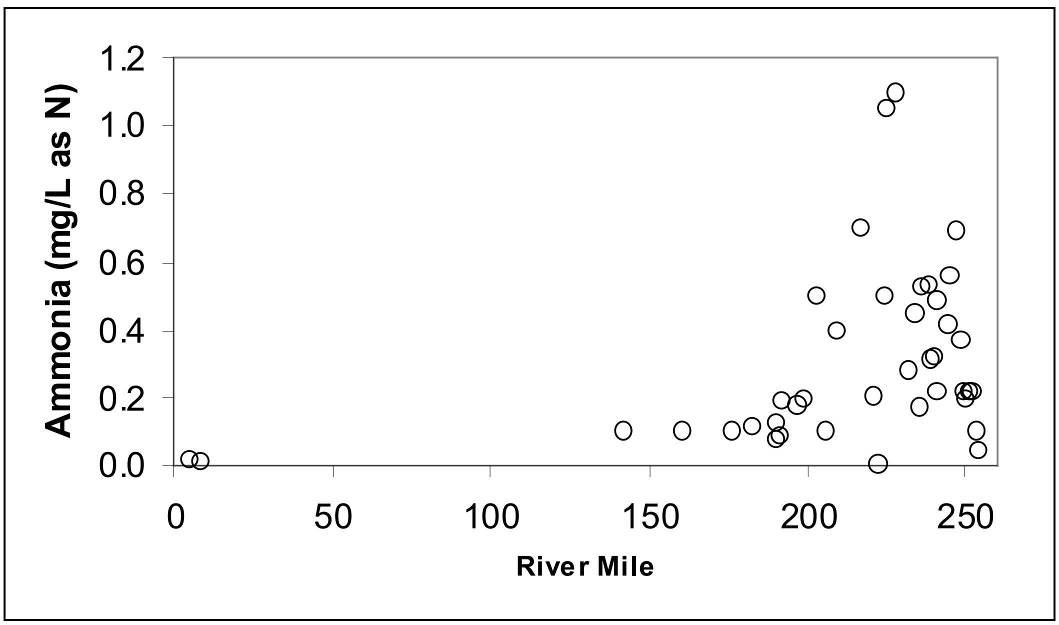


Figure E3.2-5. Median values for ammonia nitrogen (mg/L as N) measured at various sites in the Klamath River between 1950 and 2001.

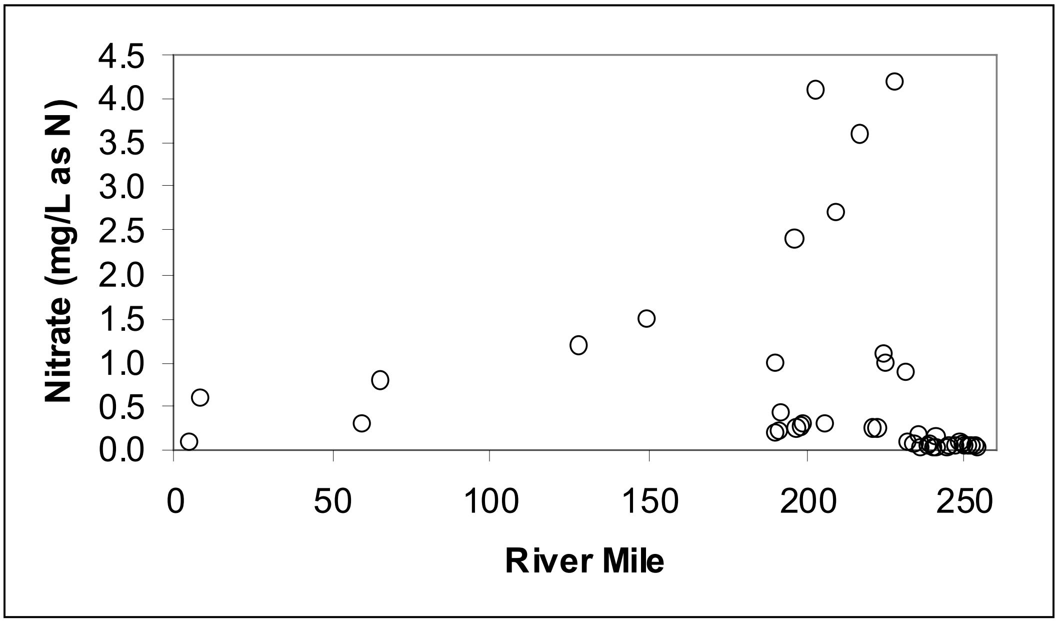


Figure E3.2-6. Median values for nitrate nitrogen (mg/L as N) measured at various sites in the Klamath River between 1950 and 2001.

The concentrations of orthophosphate phosphorus and total phosphorus measured historically at sites in the Klamath River are shown in Figure E3.2-7 and E3.2-8. Median values of ortho-phosphate phosphorus are relatively low in Upper Klamath Lake (RM 254) and Link River (RM 253), but they increase rapidly downstream in Keno reservoir. The input from Klamath Straits Drain is high in phosphorus and appears to influence orthophosphate concentrations at the sites downstream. Orthophosphate concentration decreases in the river below Iron Gate dam and reaches levels comparable to those in Upper Klamath Lake by RM 65. A cluster of high median orthophosphate concentration at sites between RM 203 and RM 228 is from the same study that produced high nitrate concentrations. Median total phosphorus concentrations follow a pattern similar to that of orthophosphate phosphorus.

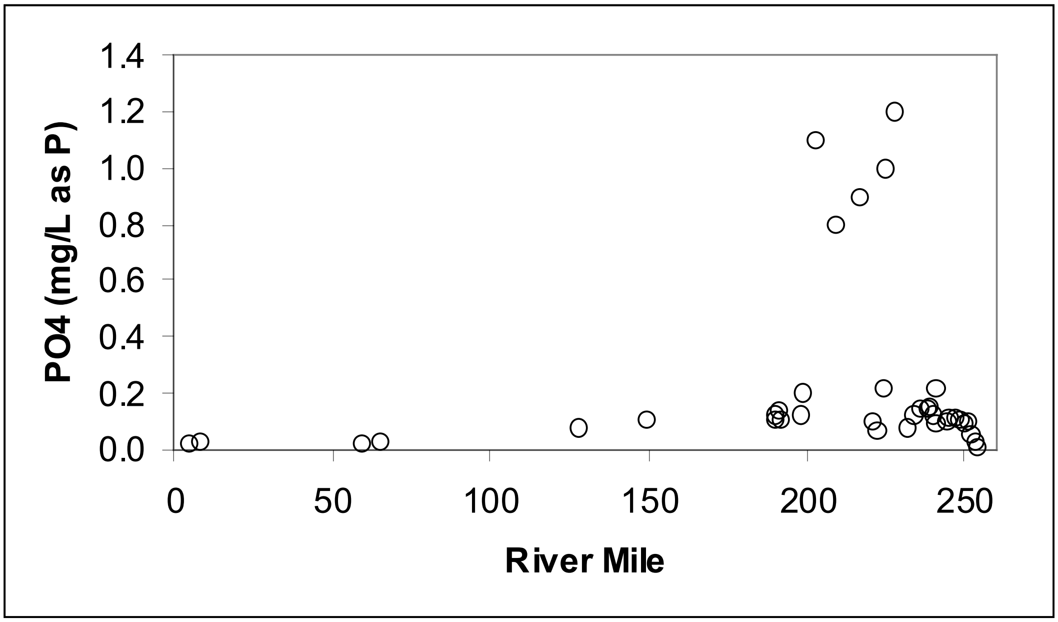


Figure E3.2-7. Median values for orthophosphate phosphorus (mg/L as P) measured at various sites in the Klamath River between 1950 and 2001.

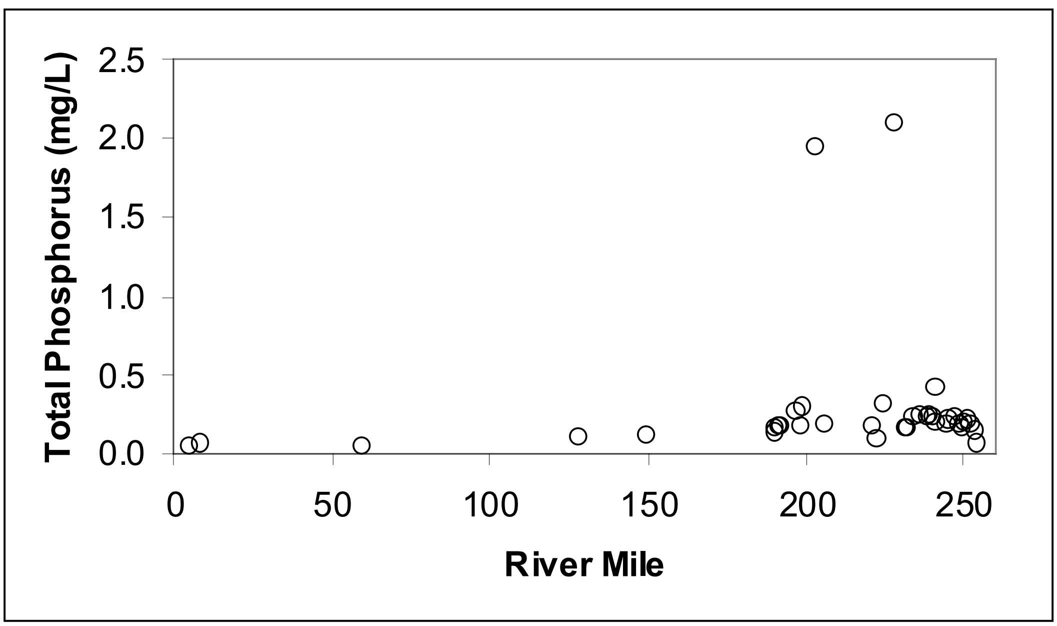


Figure E3.2-8. Median values for total phosphorus (mg/L) measured at various sites in the Klamath River between 1950 and 2001.

Organic Matter

BOD is an indirect measure of the concentration of organic matter in water, and TKN is a measure of organic nitrogen and ammonia. The waters of the Project area receive a considerable contribution of both BOD and TKN from Upper Klamath Lake. As water passes through the Project area, the organic matter is consumed or settles out and concentrations are reduced. This is reflected in the changes in BOD and TKN concentrations as illustrated in Figures E3.2-9 and E3.2-10. The low concentration of TKN at RM 222 (Figure E3.2-9) shows the influence of dilution by groundwater inputs in the J.C. Boyle bypass reach.

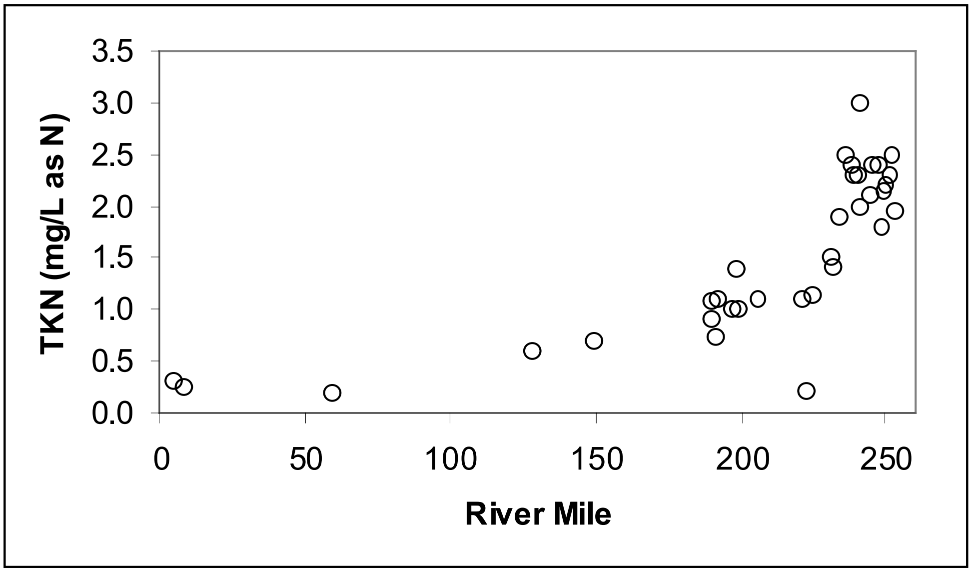


Figure E3.2-9. Median values for total Kjeldahl nitrogen (TKN, mg/L) measured at various sites in the Klamath River between 1950 and 2001.

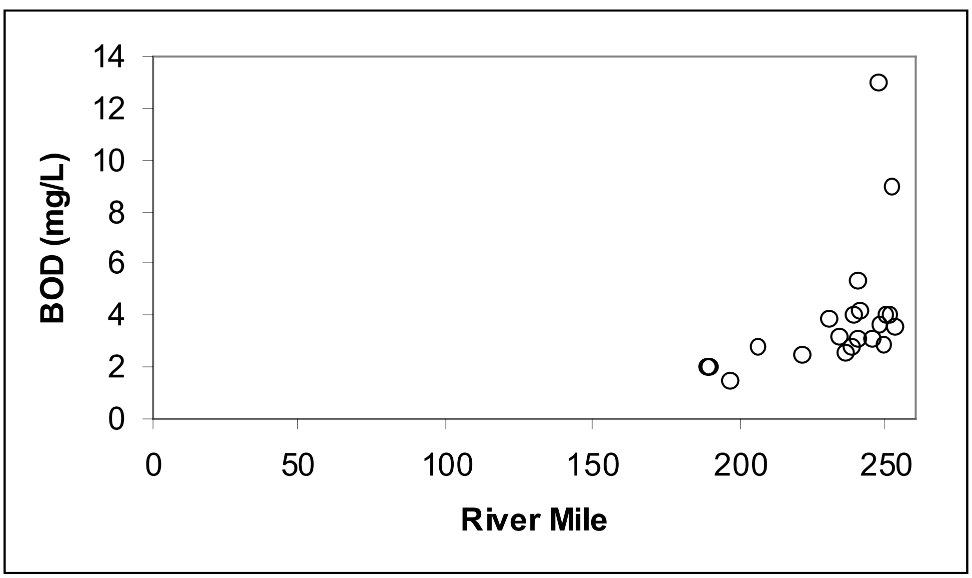


Figure E3.2-10. Median values for biochemical oxygen demand (BOD, mg/L) measured at various sites in the Klamath River between 1950 and 2001.

Turbidity

Turbidity is a measure of suspended material in the water. Inputs to Lake Ewauna (Link River, RM 253, and Klamath Straits Drain, RM 240.5) have high turbidity (Figure E3.2-11). This is reflected in the turbidity of Lake Ewauna (RM 252 to RM 248). Some settling appears to occur in Keno reservoir because sites between RM 247 and RM 234 have relatively lower turbidity. The trend in turbidity continues to decrease until near the mouth (RM 8), where median turbidity is noticeably higher than its nearby sites.

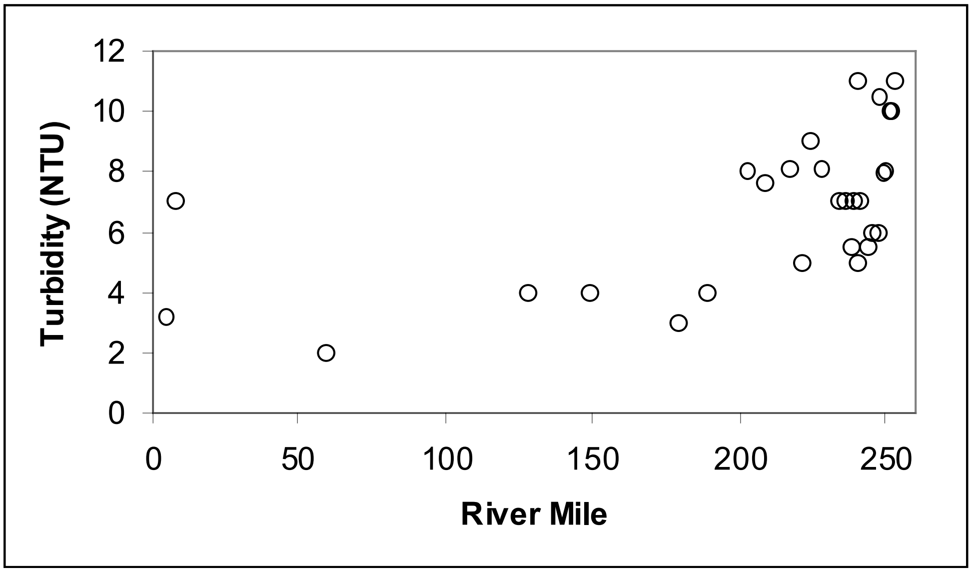


Figure E3.2-11. Median values for turbidity (NTU) measured at various sites in the Klamath River between 1950 and 2001.

Chlorophyll *a*

Relatively few sites along the length of the Klamath River were sampled for chlorophyll *a* (Figure E3.2-12). Most of the historical chlorophyll *a* measurements have been taken in the summer so the median values are representative of summer conditions. However, the resolution of the collected data is not fine enough to discern shorter duration events, such as algal blooms. Chlorophyll *a* samples from Keno reservoir above Keno dam (RM 231 to RM253) tend to have high median chlorophyll *a* concentrations, greater than 15 micrograms per liter (µg/L). Below Keno dam, median chlorophyll *a* concentrations are considerably lower.

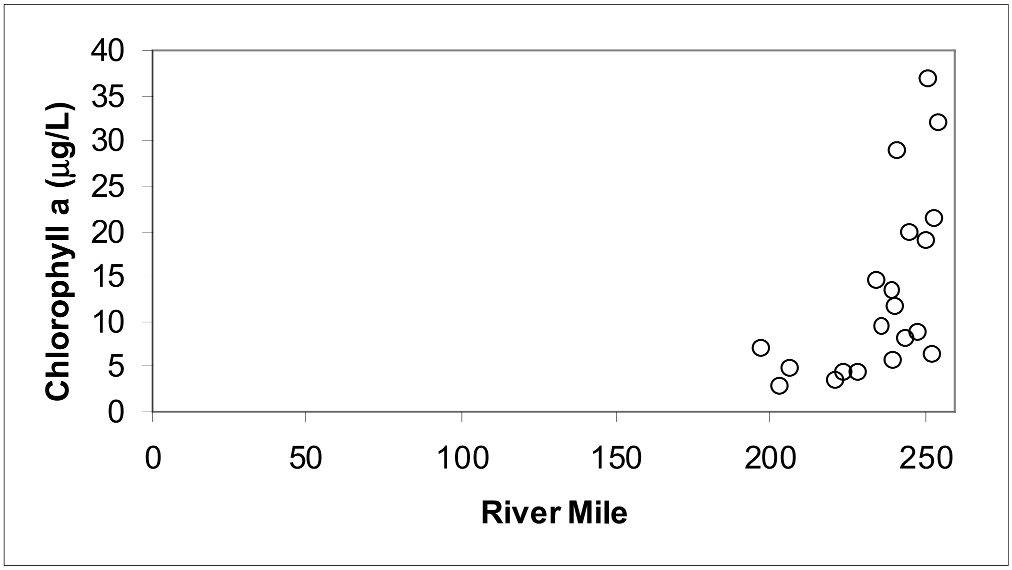


Figure E3.2-12. Median values for chlorophyll *a* (µg/L) measured at various sites in the Klamath River between 1950 and 2001.

pH

Aquatic organisms can affect pH through photosynthesis and respiration. During dense algal blooms, uptake of carbon dioxide during photosynthesis can raise the pH in a lake. Conversely, respiration by plants and other organisms can release carbon dioxide to the water and lower the pH. These effects can cause pH in a water body to vary considerably during a 24-hour cycle. Although the resolution of the historical data is not fine enough to demonstrate the daily cycle, the influence of biota on pH can be discerned in the data. Median pH values for sites with high median chlorophyll *a* concentrations tend to be higher than other sites (Figure E3.2-13).

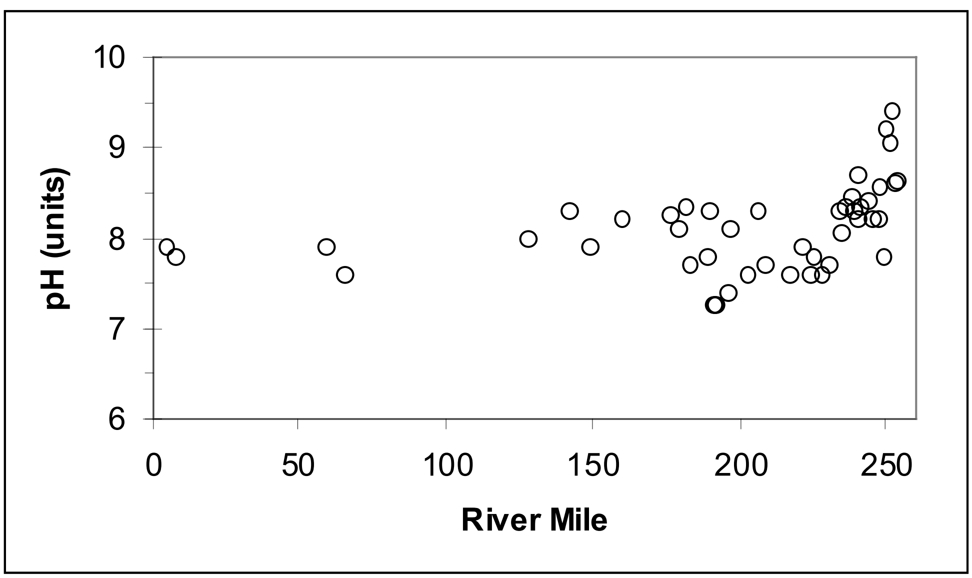


Figure E3.2-13. Median values for pH (units) measured at various sites in the Klamath River.

Interpretation of Spatial Trends

The overall picture of the Klamath River that emerged from the historical data was one of higher production and organic matter in the upper reaches of the river (Lake Ewauna and Keno reservoir), changing to lower production and lesser organic matter in the lower reaches of the river. Based on the available historical data, Upper Klamath Lake and Klamath Straits Drain appear to be important sources of BOD, organic nitrogen, dissolved solids, turbidity (suspended solids), and phosphorus. The Shasta River also contributed dissolved solids and phosphorus. The actual effect of these contributions on Klamath River water quality likely depended on the seasonality of the inputs and their discharge relative to the Klamath River.

Although there were insufficient data to characterize other tributaries to the Klamath River, comparison between sites on the river suggests where material inputs to the Klamath River occurred. For example, average nitrate nitrogen concentration was notably higher than at other sites in Keno reservoir near Keno (RM 231), in the samples taken below Fall Creek prior to the construction of Iron Gate dam (RM 196), below the Iron Gate fish hatchery (RM 189.5), and in the Klamath River near Hamburg (RM 149).

The Scott River enters the Klamath River a short distance upstream from Hamburg and could have been a source of nitrate loading to the river. Average nitrate nitrogen and ammonia nitrogen concentrations in the Iron Gate dam outflow (RM 189.7) were noticeably lower than the concentrations measured just downstream (RM 189.5), suggesting that a source of nitrogen occurred between the two sites. Both the Iron Gate fish hatchery discharge and the mouth of Bogus Creek are located in this short reach of river. The site on the Klamath below Fall Creek prior to construction of Iron Gate dam (RM 196) was also downstream of the fish facility on Fall Creek. The high average concentration of nitrate nitrogen in the Klamath River near Keno (RM 231) relative to Lake Ewauna (RM 232, 233) may have reflected nitrification of the abundant ammonia and organic nitrogen present in Lake Ewauna and Keno reservoir.

Median turbidity was higher in the Klamath River near Klamath (RM 8) than in other sites below Iron Gate dam, suggesting that there is a source of turbidity to the Klamath River downstream from Orleans.

E3.2.2.2 Temporal Trends in the Previous Data

The aspects of the data mentioned above that cause difficulty for spatial analysis also apply to temporal analysis. Many of the constituents and sites for which data were collected did not have sufficient numbers of data points, or were not collected frequently enough or for a long enough span of time, to be useful for temporal analysis. However, several of the more commonly sampled constituents and sites did have sufficient data to make temporal analysis feasible. The constituents used for temporal analysis are alkalinity, ammonia nitrogen, chlorophyll *a,* dissolved oxygen, nitrate nitrogen, orthophosphorus, pH, TKN, and turbidity. The sites are listed in Table E3.2-7. Not every combination of site and constituent listed in Table E3.2-7 was suitable for use in the analysis.

Table E3.2-7. Sites used for temporal analysis of Klamath River historical data.

Site Location	Site Description
RM 5	Klamath River near Klamath Glen
RM 128	Klamath River near Seiad
RM 189.5	Klamath River below Iron Gate fish hatchery
RM 240.5	Klamath Straits Drain
RM 253	Link River near mouth

In general, the data are not amenable to standard time series analysis, which typically requires evenly spaced data. Likewise, the usual requirements for standard parametric analysis are typically not met. To overcome these impediments, the historical data were analyzed graphically. Each constituent under consideration was plotted against date and day of the year (Julian day) in order to detect both long-term trends and seasonal effects. A third-order polynomial was fit to the data for each graph, and the correlation coefficient of the fitted curve was determined. The results of the analysis are summarized in Table E3.2-8.

Table E3.2-8. Correlation coefficients (R^2) for third-order polynomial fit to Klamath River water quality data.

Parameter	RM	R^2 Date	R^2 Julian Day
Alkalinity	189.5	0.0626	0.0650
Ammonia Nitrogen	5	0.0219	0.0060
Ammonia Nitrogen	253	0.1353	**0.4282**
Chlorophyll *a*	240.5	0.1350	0.0088
Chlorophyll *a*	253	0.1310	**0.1533**
Dissolved Oxygen	240.5	0.0126	**0.4115**
Dissolved Oxygen	253	0.1363	**0.4733**
Nitrate Nitrogen	5	**0.2286**	0.0428
Nitrate Nitrogen	128	**0.2893**	**0.3233**
Nitrate Nitrogen	189.5	**0.3677**	**0.2507**
Nitrate Nitrogen	240.5	0.0594	0.1413
Nitrate Nitrogen	253	0.0047	**0.2517**
Orthophosphate	5	0.1124	0.0304
Orthophosphate	240.5	0.0879	**0.2514**
Orthophosphate	253	0.1095	0.0406
pH	5	**0.2080**	0.1218
pH	253	0.0863	**0.4808**
Total Kjeldahl Nitrogen	5	0.0513	0.1095

Table E3.2-8. Correlation coefficients (R^2) for third-order polynomial fit to Klamath River water quality data.

Parameter	RM	R^2 Date	R^2 Julian Day
Total Kjeldahl Nitrogen	189.5	0.0424	**0.3058**
Total Kjeldahl Nitrogen	253	0.0422	**0.5863**
Turbidity	5	0.1148	**0.1608**
Turbidity	189.5	0.0305	**0.2563**
Turbidity	253	0.1287	0.1153

Note: Analysis was conducted to detect long-term trends (R^2 Date), and seasonal effects (R^2 Julian Day). Coefficients greater than 0.15, in bold, suggest that there is a temporal trend in the data.

Seasonal Trends

Discernible seasonal trends are evident for several constituents and sites. These include ammonia nitrogen in Link River (RM 253), chlorophyll *a* in Link River, dissolved oxygen at several sites, nitrate nitrogen at Seiad (RM 128) and below the Klamath fish hatchery (RM 189.5), ortho-phosphate in Klamath Straits Drain (RM 240.5), TKN in Link River (RM 253) and below the fish hatchery (RM 189.5), and turbidity below the fish hatchery (RM 189.5) and near the mouth (RM 5) (Figures E3.2-14 through E3.2-26).

Ammonia nitrogen in Link River and nitrate nitrogen below the fish hatchery and at Seaid exhibit a similar pattern of minimum concentration in June, July, and August, increasing to maximum concentration in December and January (Figures E3.2-14 to 16). In contrast, TKN entering Lake Ewauna from Link River is at a minimum during March and April, reaches a maximum in August and September, and then decreases through the winter (Figure E3.2-17). Although sampling for chlorophyll *a* has historically been limited to summer months, the seasonal pattern for chlorophyll at Link River, most likely a reflection of conditions in Upper Klamath Lake, is similar to that of TKN; minimum values occur in May and June, increasing to maximum values in August and September (Figure E3.2-18). Orthophosphate phosphorus in Klamath Straits Drain (RM 240.5) has relatively low values in winter that increase in spring to maximum values in June and July and then decrease through the fall (Figure E3.2-19).

Dissolved oxygen follows a distinct seasonal pattern, reflecting the interaction of oxygen solubility and temperature. As water temperatures warm through the summer, dissolved oxygen concentration decreases, as indicated in Figure E3.2-20, where all sites are plotted. The many low values seen in Figure E3.2-20 are largely taken from sites in Lake Ewauna (Keno reservoir).

Turbidity in the Klamath River below the Iron Gate fish hatchery is generally quite low and relatively uniform, but it exhibits a seasonal pattern of higher values in December through March and minimum values in July through September (Figure E3.2-21). A similar pattern, although with considerably higher values and greater variability, can be seen in the Klamath River near Klamath Glen (RM 5) (Figure E3.2-22).

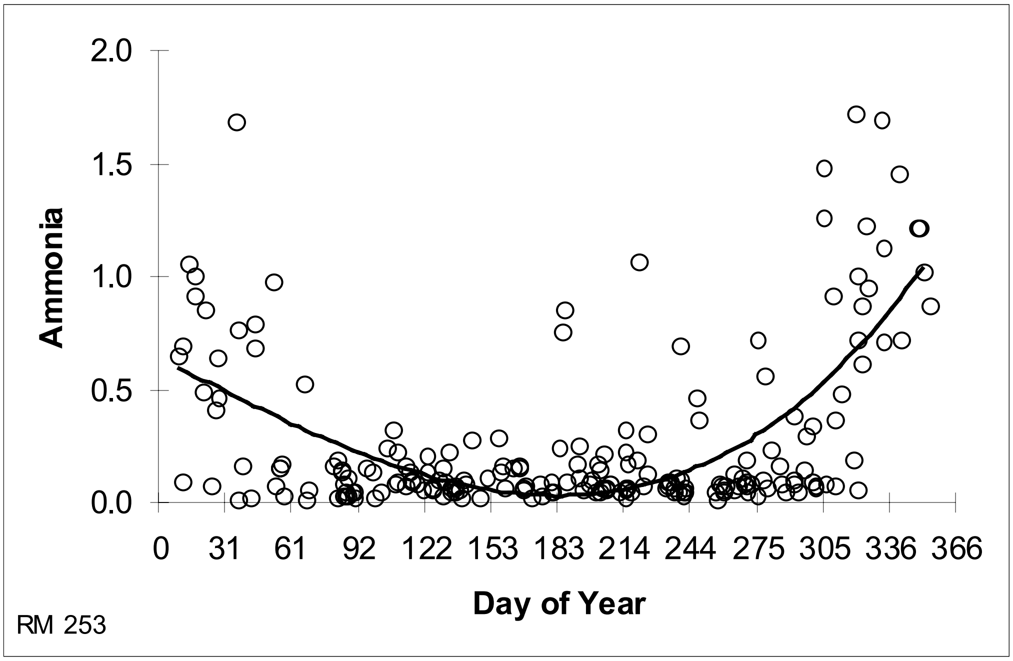


Figure E3.2-14. Ammonia nitrogen values (mg/L as N) measured in Link River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data.

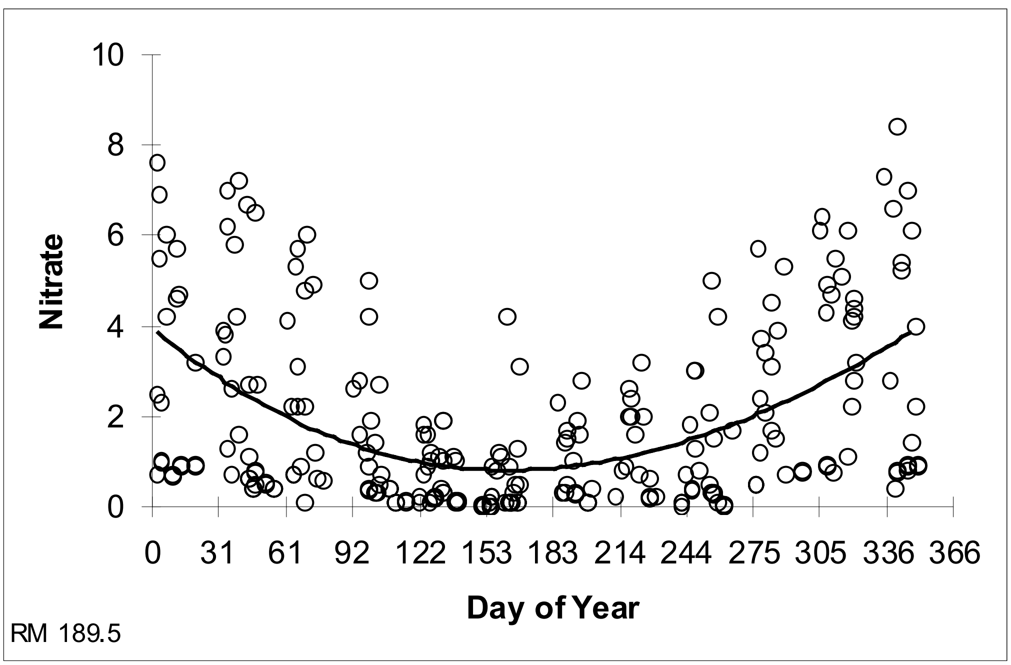


Figure E3.2-15. Nitrate nitrogen values (mg/L as N) measured in the Klamath River downstream of the Klamath River fish hatchery in 1950 through 2001. A third order polynomial curve is fitted to the data.

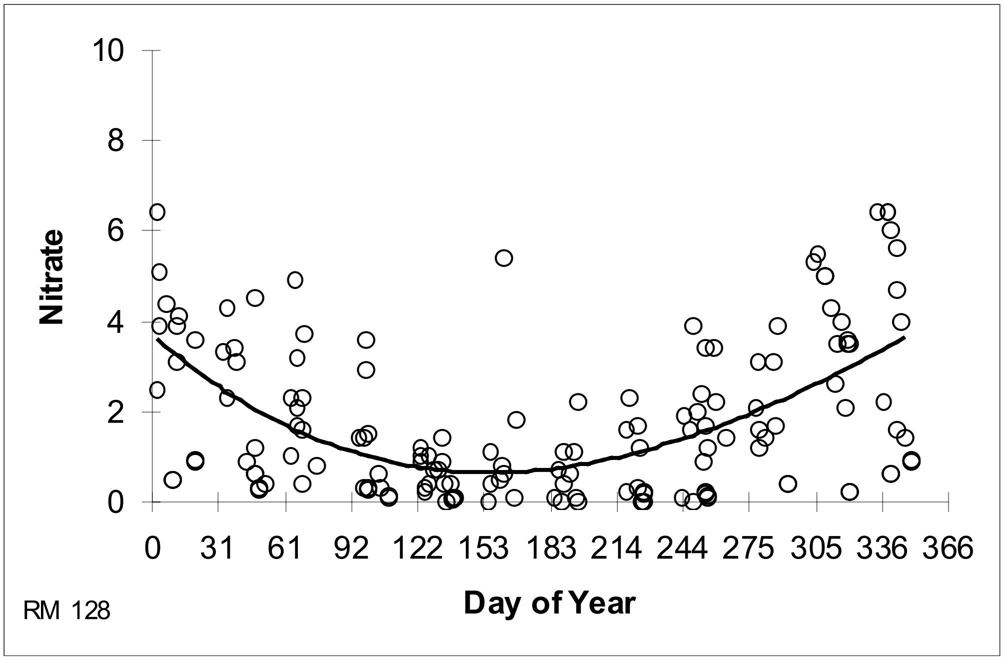


Figure 3.2-16. Nitrate nitrogen values (mg/L as N) measured in the Klamath River near Seiad in 1950 through 2001. A third order polynomial curve is fitted to the data.

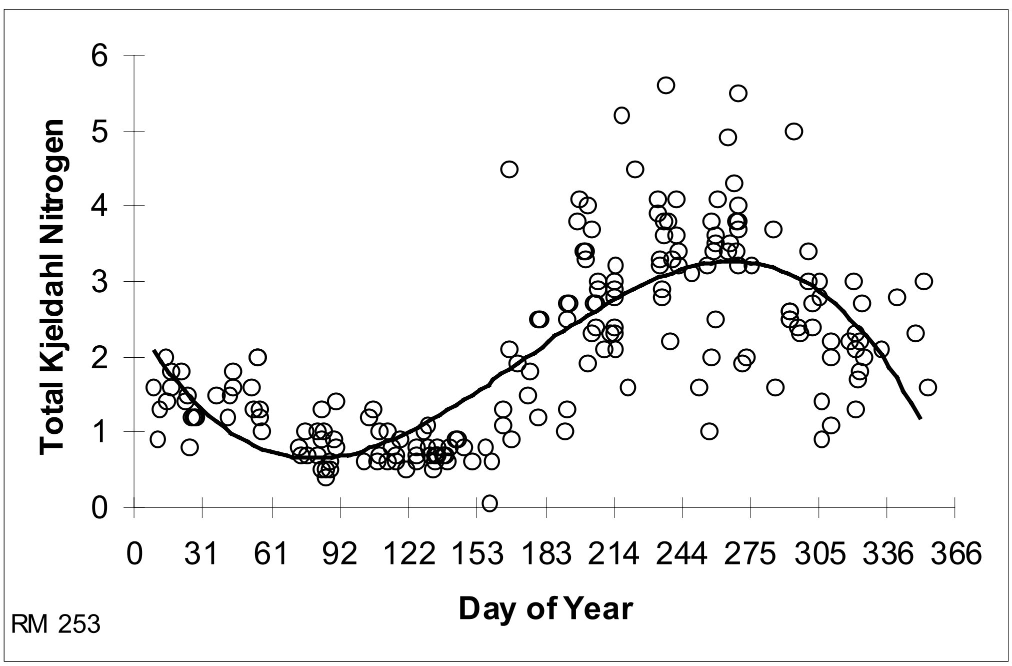


Figure E3.2-17. Total Kjeldahl nitrogen values (mg/L as N) measured in Link River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data.

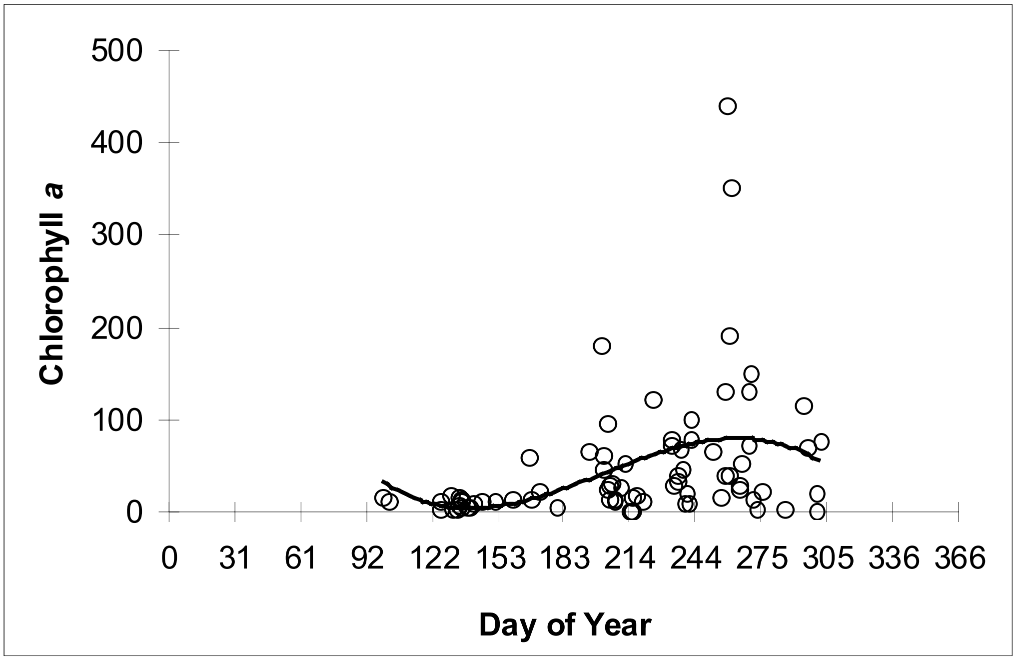


Figure E3.2-18. Chlorophyll *a* values (µg/L) measured in Link River near the mouth (RM 5) in 1950 through 2001. A third order polynomial curve is fitted to the data.

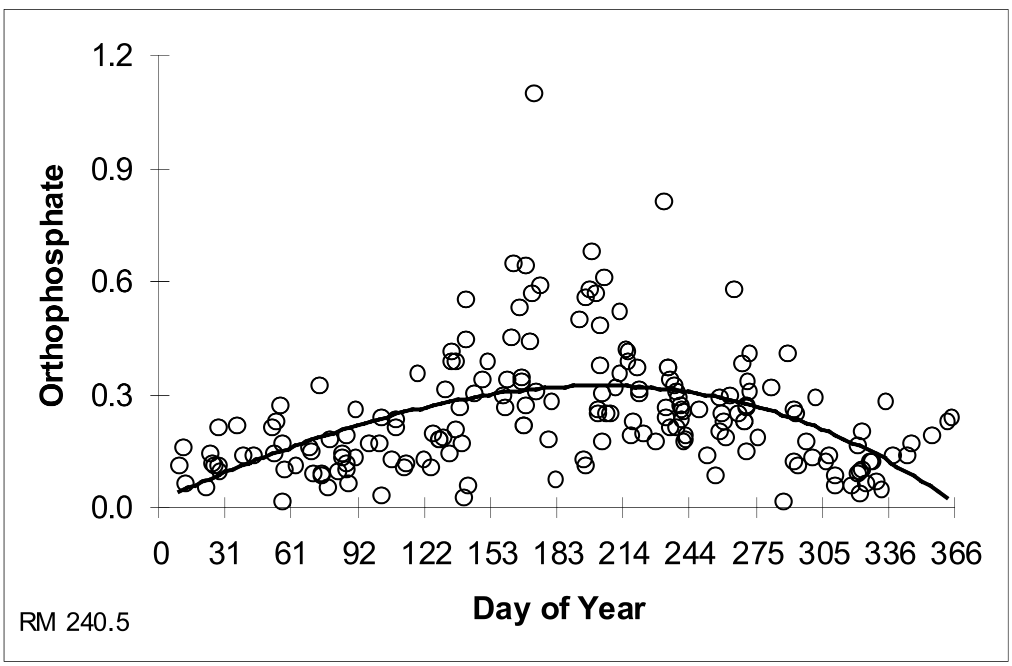


Figure E3.2-19. Orthophosphate phosphorus values (mg/L as P) measured in the Klamath Straits Drain in 1950 through 2001. A third order polynomial curve is fitted to the data.

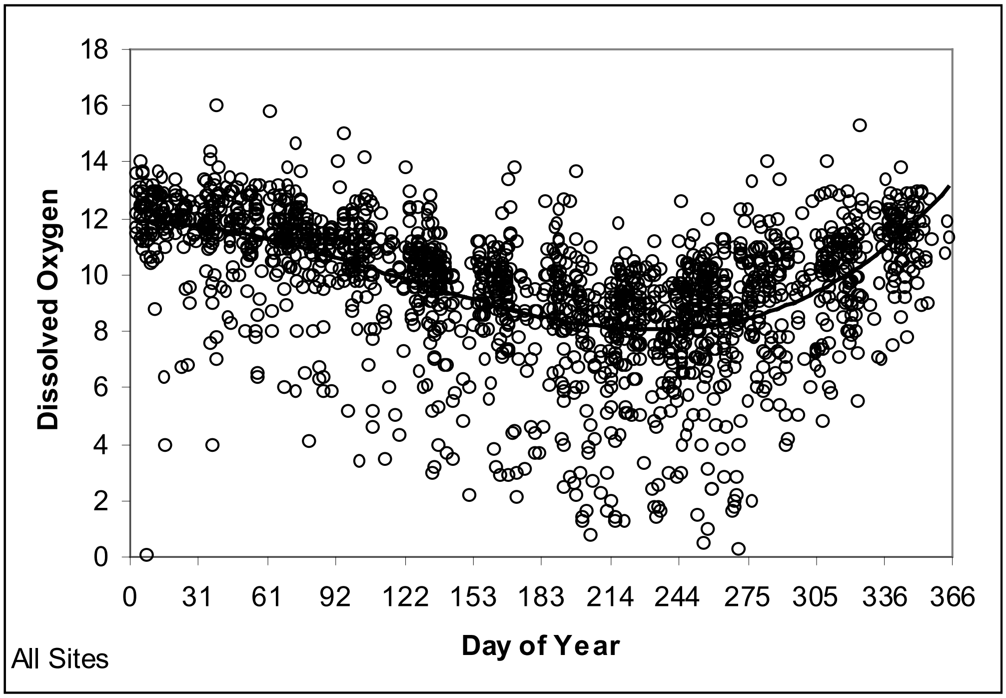


Figure E3.2-20. Dissolved oxygen values (mg/L) measured at various sites in the Klamath River in 1950 through 2001. A third order polynomial curve is fitted to the data.

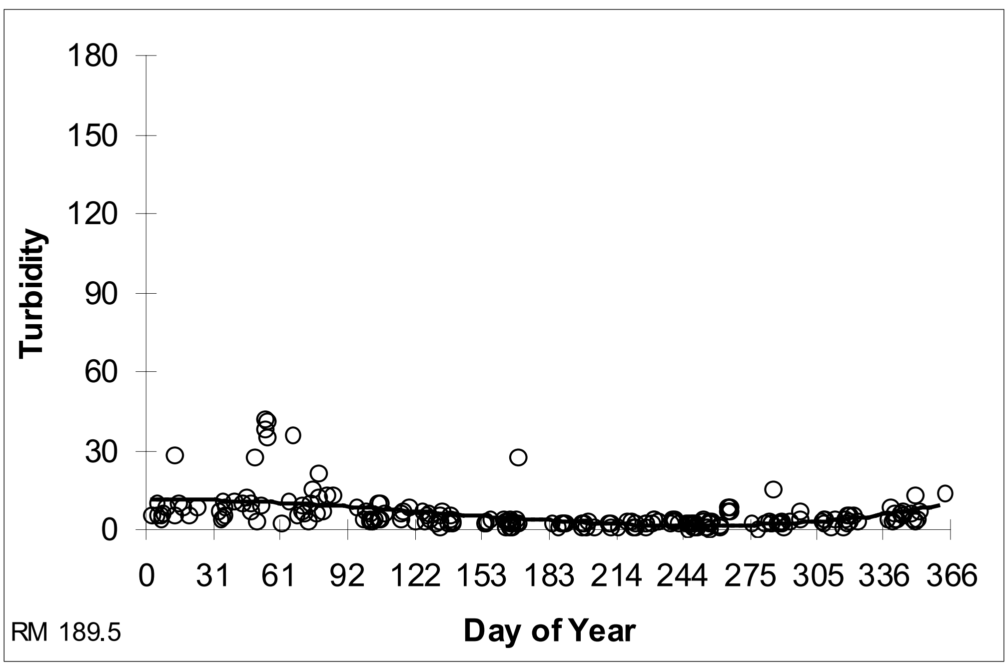


Figure E3.2-21. Turbidity values (NTU) measured in the Klamath River downstream of the Klamath River fish hatchery in 1950 through 2001. A third order polynomial curve is fitted to the data.

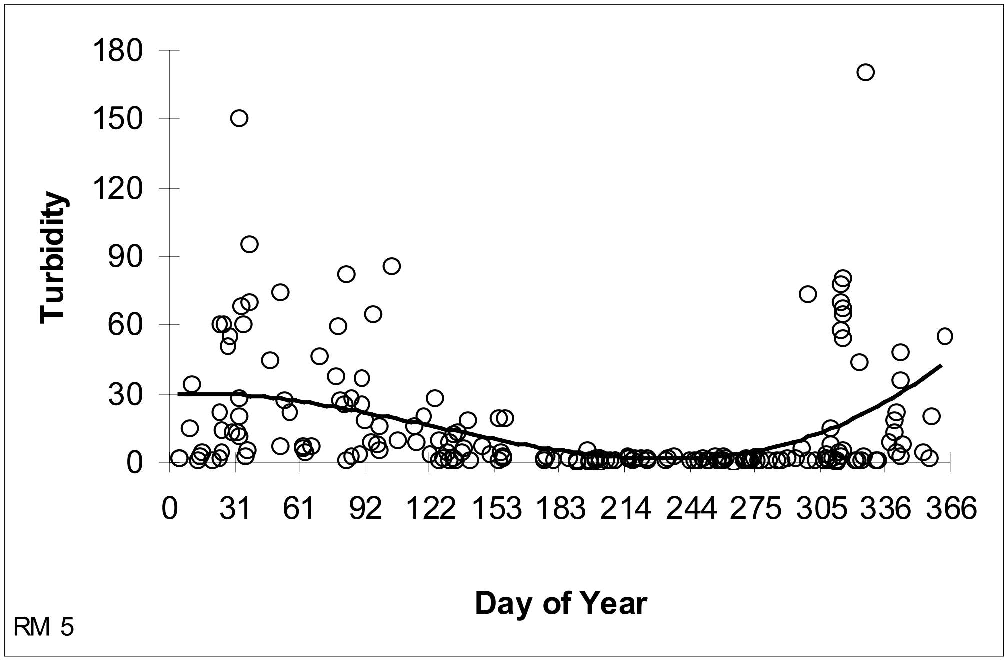


Figure E3.2-22. Turbidity values (NTU) measured in the Klamath River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data.

Long-Term Trends

Few long-term trends were evident in the historical data. The exceptions were nitrate nitrogen at several sites, TKN in the Klamath River below the fish hatchery, and pH in the Klamath River near the mouth. A distinctive pattern occurs in the abundance of nitrate nitrogen at three sites; relatively high and variable values occur prior to approximately 1980, and lower and less variable values occur after 1980. The pattern is similar below the fish hatchery (RM 189.5), at Seiad (RM 128), and near Klamath Glen (RM 5), although the absolute value of nitrate concentration and the magnitude of the change decreases with distance downstream (Figures E3.2-23 to E3.2-26). A similar change does not occur in Link River (Figure E3.2-27). The polynomial fit to TKN data at RM 189.5 indicates a trend may exist, but inspection of the plot suggests that the trend is an artifact. A linear fit to the data indicates that no trend exists ($R^2 = 0.0032$). An increasing trend in pH is evident in measurements made near the mouth of the Klamath River (RM 5) (Figure E3.2-28).

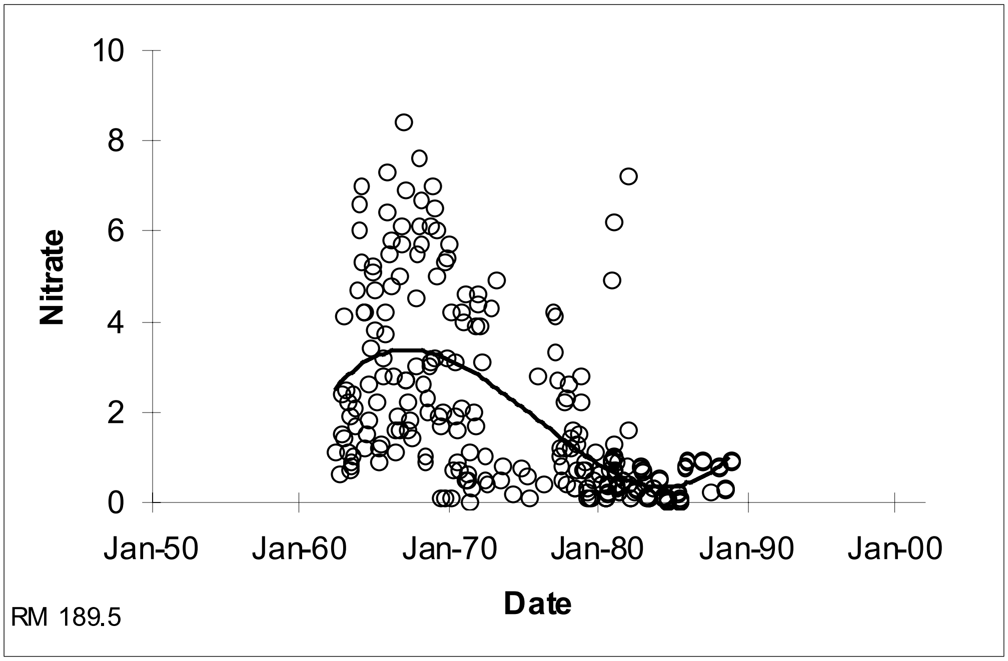


Figure E3.2-23. Nitrate nitrogen values (mg/L as N) measured in the Klamath River downstream of the Klamath River fish hatchery in 1950 through 2001. A third order polynomial curve is fitted to the data.

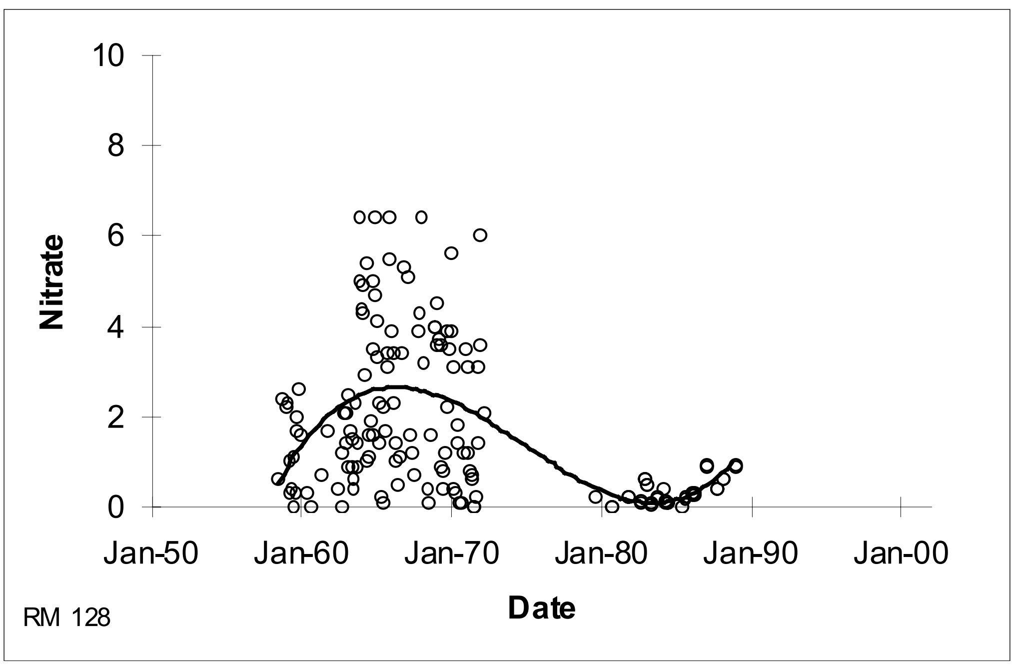


Figure E3.2-24. Nitrate nitrogen values (mg/L as N) measured in the Klamath River near Seiad in 1950 through 2001. A third order polynomial curve is fitted to the data

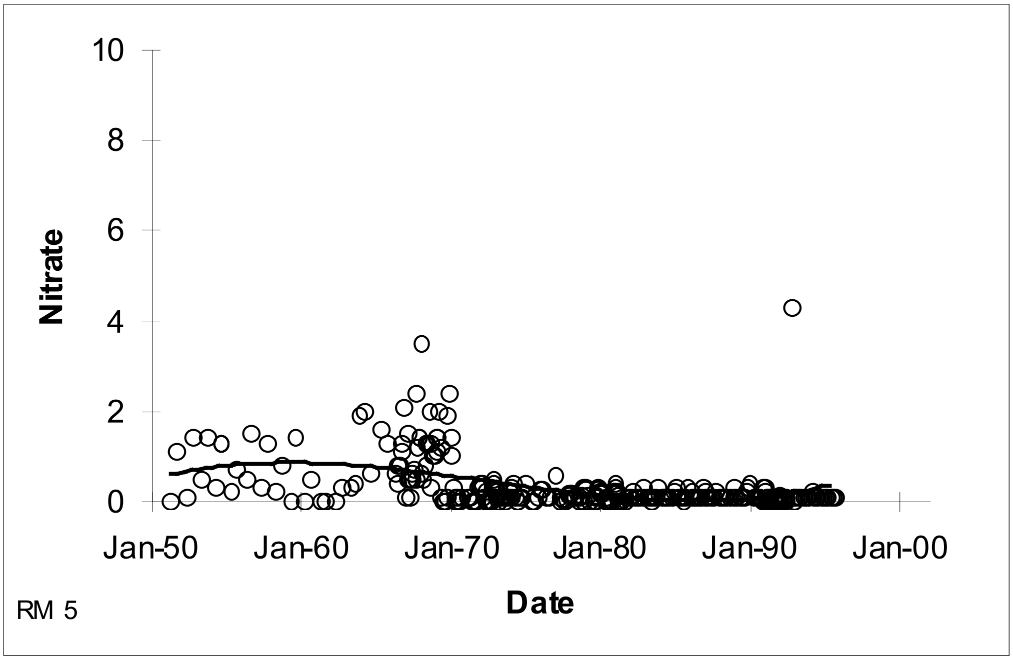


Figure E3.2-25. Nitrate nitrogen values (mg/L as N) measured in the Klamath River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data.

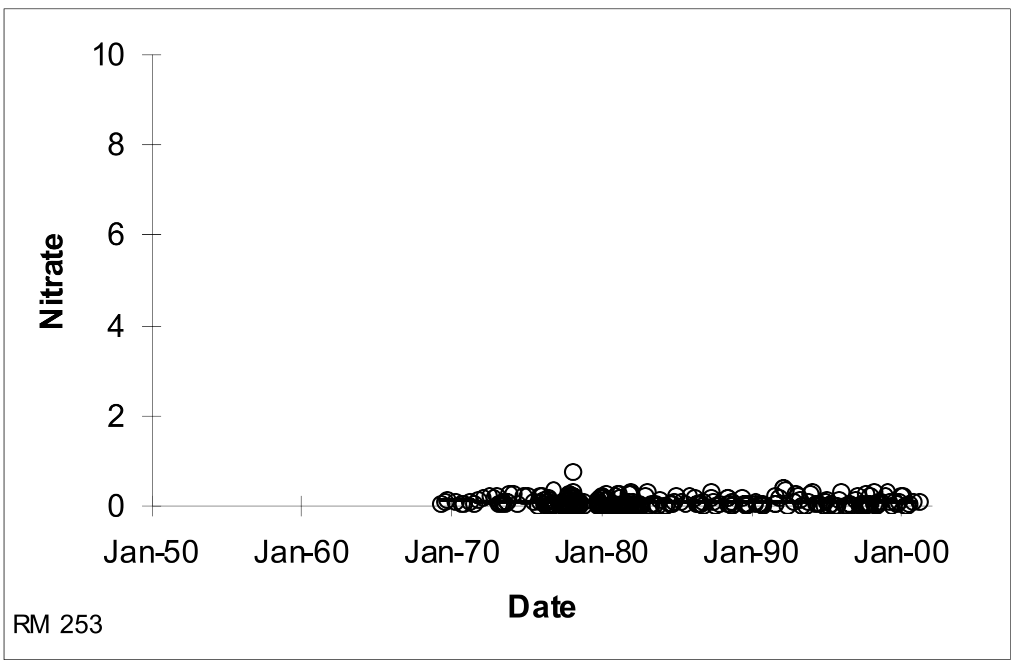


Figure E3.2-26. Nitrate nitrogen values (mg/L as N) measured in Link River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data

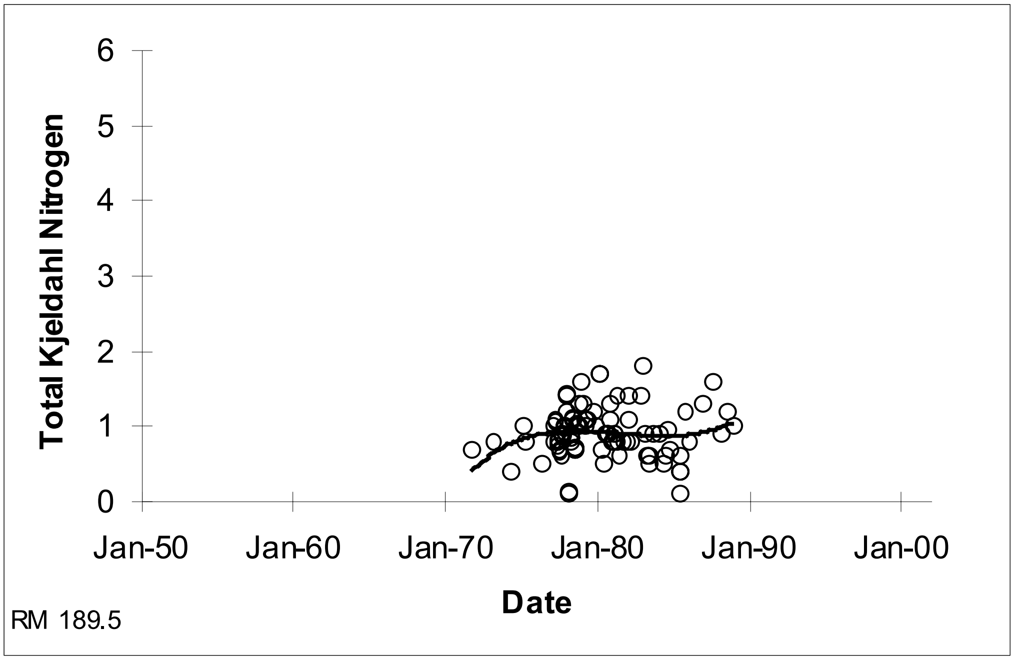


Figure E3.2-27. Total Kjeldahl nitrogen values (mg/L as N) measured in the Klamath River downstream of the Klamath River fish hatchery in 1950 through 2001. A third order polynomial curve is fitted to the data.

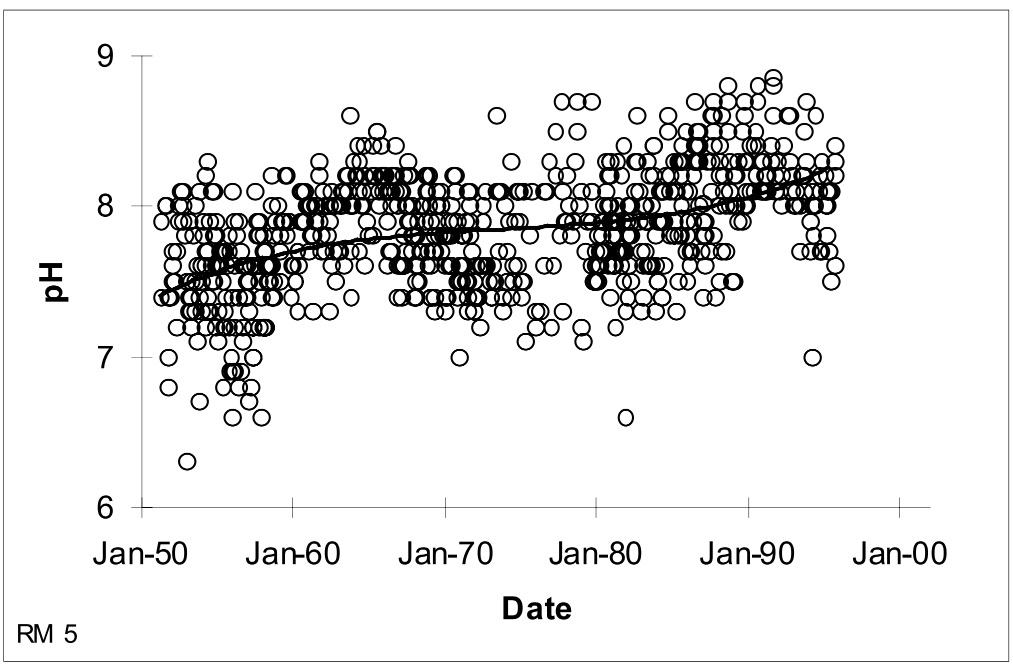


Figure E3.2-28. pH (units) measured in the Klamath River near the mouth in 1950 through 2001. A third order polynomial curve is fitted to the data.

E3.3 CURRENT WATER QUALITY CONDITIONS

This section describes current water quality conditions in Upper Klamath Lake and the Klamath River in the vicinity of the Project. The section is organized by areas or reaches in the Project vicinity: Upper Klamath Lake, Lake Ewauna/Keno reservoir, river reaches, Project reservoirs, and the Klamath River below Iron Gate dam.

Current water quality conditions in Upper Klamath Lake are described using available literature and data sources as cited. The discussion of current water quality conditions in the Klamath River between Link River dam and the Shasta River is based on grab sample data collected by PacifiCorp from 2000 through 2003, grab sample data provided to PacifiCorp by USBR for that same period, hourly temperature data collected by Pacificorp from 2000 through 2003, and hourly temperature data provided to PacifiCorp by BLM. It includes data collected by PacifiCorp between Upper Klamath Lake (Fremont Bridge) and the mouth of the Shasta River during 2000 through 2003, as well as data collected by USBR between Upper Klamath Lake and Keno dam. Section 3.0 of the Water Resources FTR provides details on the purpose, methods, and results of these studies.

Thirty-three sites on the Klamath River between Upper Klamath Lake and the mouth of the Shasta River were sampled for water quality constituents in 2000 through 2003. Sampling site locations are shown in Figure E3.3-1. The number of samples collected by site and by year is presented in Table E3.3-1.

In general, PacifiCorp sampled reservoir and river sites monthly during March through November in 2000 through 2003. USBR sampled sites in Lake Ewauna and Keno reservoir, plus additional sites on the Klamath River, biweekly during May through October in 2000 and 2002. USBR has shared its data with PacifiCorp for consideration in this report. Not every site was sampled for the entire time. On three occasions in 2002 (May, July, and September), a 3-day synoptic sampling event was conducted. The purpose of this 3-day effort was to collect data representing smaller scale variations in time and space than were obtained during the regular monthly sampling.

PacifiCorp installed temperature data loggers (Onset TidBits®) at 26 additional sites in the Klamath River to gather hourly temperature data. The sites and dates recorded are listed in Table E3.3-2. In addition, vertical arrays of temperature data loggers collecting hourly temperature data have been placed near the dams in the main Project reservoirs from 2000 through 2003.

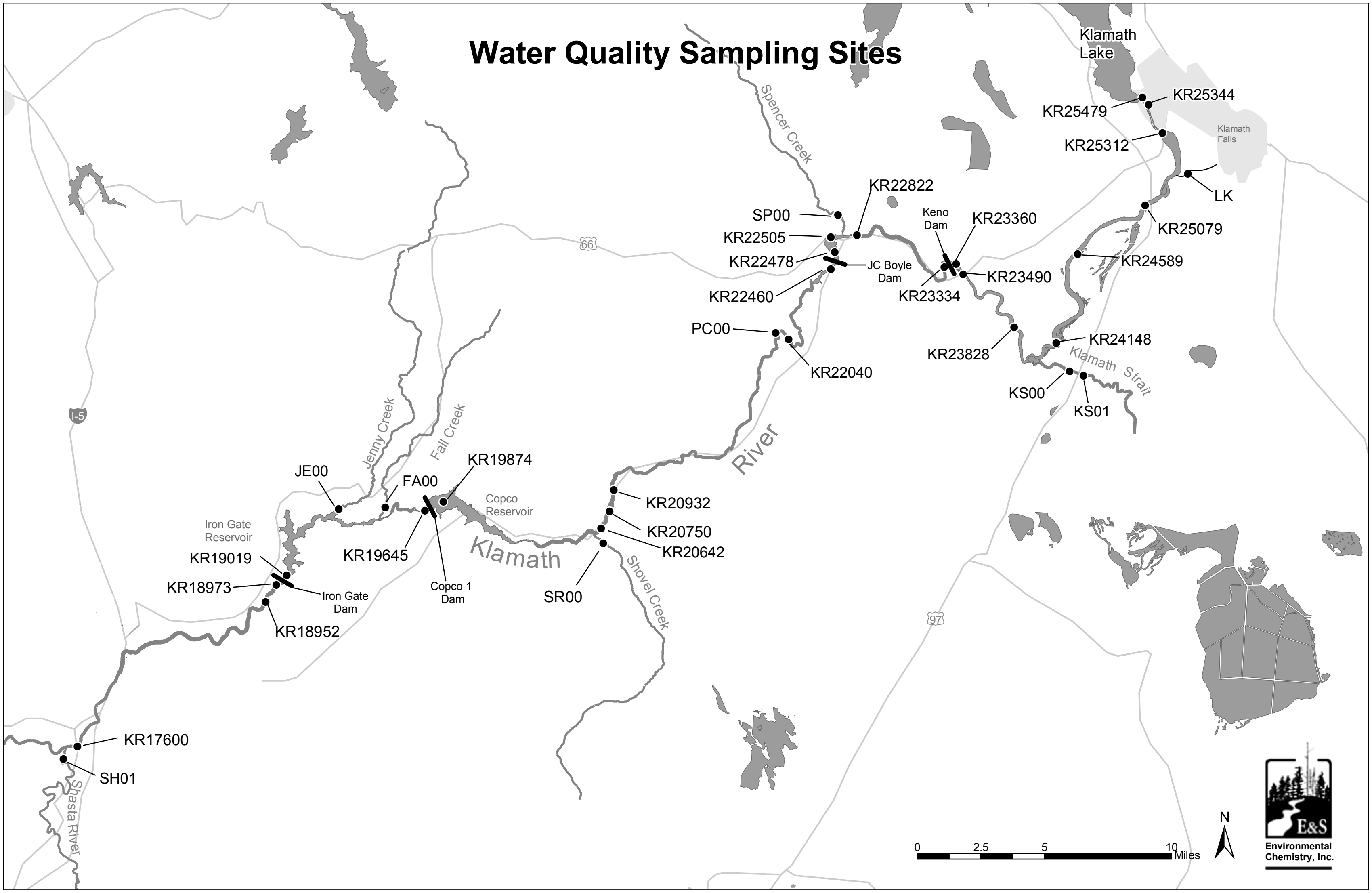


Figure E3.3-1. PacifiCorp and USBR water quality sampling sites in the Klamath River, 2000-2003 (see Table E3.3-1 for sites sampled by year).

Table E3.3-1. Sample site locations and number of dates sampled for water quality data in the Project area.

Site ID*	Site Name	2000	2001	2002	2003
KR25479	Upper Klamath Lake at Fremont St. Bridge			8	1
KR25344	Link River near East Side powerhouse			13	
KR25312	Link River at mouth			20	9
LK	Lost River diversion canal at Klamath River			3	
KR25079	Klamath River at South-Side Bypass Bridge			14	
KR24589	Klamath River at Miller Island boat ramp	13		14	
KR24148	Klamath River upstream of Klamath Straits Drain	1		13	
KS01	Klamath Straits Drain pumping plant F	14		14	
KS00	Klamath Straits Drain 200 feet downstream of pumping plant F	1		7	
KR23828	Klamath River directly south of Hill 4315			14	
KR23490	Klamath River at Keno Bridge (Hwy. 66)	14		14	9
KR23360	Keno reservoir at log boom		8		
KR23334	Klamath River below Keno dam			15	9
KR22822	Klamath River above J.C. Boyle reservoir			16	9
SP00	Spencer Creek		1	10	1
KR22505	J.C. Boyle reservoir at deepest point			8	
KR22478	J.C. Boyle reservoir at log boom	8	6	15	8
KR22460	Klamath River below J.C. Boyle dam			15	9
KR22040	J.C. Boyle bypass (bottom)			16	9
PC00	J.C. Boyle power plant tailrace	1		13	1
KR20932	Klamath River near Stateline			10	
KR20750	Klamath River above Copco			11	
KR20642	Klamath River upstream of Shovel Creek	13	8	9	9
SR00	Shovel Creek			11	1
KR19874	Copco Lake near Copco	8	9	14	9
KR19645	Copco dam outflow			9	9
FA00	Fall Creek near the mouth	1		9	1
JE00	Jenny Creek near the mouth			9	1
KR19019	Iron Gate reservoir near Hornbrook	8	9	14	9
KR18973	Iron Gate dam outflow	13	9	9	9
KR17600	Klamath River upstream of Shasta River			7	
SH01	Shasta River at mouth	12		11	

*Site ID codes are based on river mile. A two-letter code identifies the water body, and a two- or five-number numeric code identifies the river mile, measured from the mouth. Thus, KR22460 identifies a site on the Klamath River at RM 224.60 (below J.C. Boyle dam). River miles on the Klamath River are based on GIS river coverage, while river miles for tributaries are estimates to the nearest mile.

Table E3.3-2. Location and dates of temperature data collection at sites in the Project area.

Location	2001	2002	2003
Link River Dam Fish Ladder	05/11-10/04		04/30-11/23
Link River Bottom Upstream of East Side Powerhouse	07/17-12/31	01/01-10/23	05/07-11/23
East Side Powerhouse Tailrace	05/11-12/31	01/01-05/05	
Keno Fish Ladder	05/11-12/31	01/01-05/02	05/07-11/23
Keno Reach at USGS Gauge	05/14-12/31	01/01-05/05	
Keno Reach Bottom at Gun Club	05/11-07/17	05/07-10/23	05/07-11/23
Spencer Creek	05/11-12/31	01/01-10/24	04/30-11/23
J.C. Boyle Bypass Top	05/11-12-31	01/01-10/24	05/07-11/23
J.C. Boyle Bypass Halfway from Diversion to Powerhouse	07/17-09/20		
J.C. Boyle Bypass Bottom above Powerhouse	07/24-12/31	01/01-10/23	05/07-11/23
J.C. Boyle Powerhouse Tailrace	05/11-12/31	01/01-10/23	05/07-11/23
J.C. Boyle Peaking Reach at USGS Gauge	07/17-12-31	01/01-05/27	
J.C. Boyle Peaking Reach at Stateline Recreation Site	07/18-10/15		
J.C. Boyle Peaking Reach Upstream from Shovel Creek (at angler bridge)	07/24-10/15	05/05-10/24	04/30-11/23
Shovel Creek	05/10-12-31	01/01-10/24	05/06-11/23
Copco No. 2 Reservoir Upstream of Dam	10/15-12/31	01/01-05/06	
Top of Copco No. 2 Bypass Reach	10/15-12/31	01/01-05/06	
Copco No. 2 Bypass Reach Bottom	05/10-12/31	01/01-05/06	
Copco No. 2 Powerhouse			04/30-11/23
Klamath River above Iron Gate Reservoir			04/30-11/23
Jenny Creek	05/10-12/31	01/01-10/24	04/30-11/23
Fall Creek above Diversion	05/10-12/31	01/01-05/06	
Fall Creek Bottom of Bypass	10/15-12/31	01/01-05/06	
Fall Creek below Copco Access Road		05/05-06/17	04/30-11/23
Fall Creek Powerhouse Tailrace	07/18-12/31	01/01-05/06	
Iron Gate Dam at Powerhouse Tailrace	05/10-12/31	01/01-12/31	

Many of the presentations of water quality data described below are based on box plots. A box plot is a chart that indicates the central tendency of a set of values, their variability, the symmetry of the distribution, the presence of outliers (values very different from the others), and the range of the distribution. Box plots are often used to compare several sets of data. Box plots in this section use the following format:

- The lower edge of the box represents the first quartile Q1.
- A black line through the box represents the median Q2.
- The upper edge of the box represents the third quartile Q3.
- Vertical lines indicate the range of typical values.
- Individual points indicate extreme values.

The limits of the box define the interquartile range (IQR) and enclose the central 50 percent of the distribution. The vertical lines (whiskers) at the top and the bottom of the box indicate the range of "typical" data values. Whiskers extend to the largest or smallest data point that is within 1.5 times the IQR from the limits of the box. Any values beyond 1.5 times the IQR (possible outliers) are represented individually by asterisks if they are within three times the IQR, and by open circles if they are beyond three times the IQR (probable outliers).

E3.3.1 Upper Klamath Lake

Although Upper Klamath Lake is not part of the Project area, the lake's water quality is discussed here because of its importance as inflow or "boundary" conditions to water quality in the Project area. Current Project operations do not control or affect Upper Klamath Lake, nor will such control be sought as a result of this Project relicensing. Operation of Link dam at the outlet of Upper Klamath Lake is dictated by Upper Klamath Lake elevation targets and instream flow needs downstream from Iron Gate dam set by USBR's annual operations plans (currently the Klamath Irrigation Project 2003 Operations Plan).

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

Low dissolved oxygen and high pH values have been linked to high algal productivity in Upper Klamath Lake (Kann and Walker, 2001; Walker, 2001). Chlorophyll *a* concentrations exceeding 200 µL are frequently observed in the summer months (Kann and Smith, 1993). Algal blooms are accompanied by violations of Oregon's water quality standards for dissolved oxygen, pH, and free ammonia. ODEQ (2002) reports that standards violations for pH and dissolved oxygen generally occur from May to November. The pH criteria (6.5 to 9.0) were exceeded in 41 percent of 1991-1999 samples and in 89 percent of samples collected in July, the month with peak algal densities. Dissolved oxygen criteria were not met in 13 percent of 1991-1999 samples and in 35 percent of samples collected in August, the period coinciding with declining algal blooms, when fish kills have been most frequently observed (Perkins et al. 2000). Such water quality violations led to 303(d) listing of Upper Klamath Lake in 1998 by ODEQ. A total maximum daily load (TMDL) analysis was subsequently developed and published in May 2002 (ODEQ, 2002), and subsequently approved by EPA, to identify pollutant sources and load reductions designed to achieve water quality compliance.

The TMDL identified Upper Klamath Lake and Agency Lake as hypereutrophic, with high nutrient loading that promotes correspondingly high production of algae, which, in turn, modifies physical and chemical water quality characteristics that can directly diminish the survival and production of fish populations. Year-to-year variations in the timing and development of algal blooms during late spring and early summer are strongly dependent on water temperature. The TMDL establishes total phosphorous loading targets as the primary method of improving lake water quality. Statistical analysis and deterministic modeling showed that pH levels can be reduced to levels that benefit aquatic life when total phosphorus loading rates are reduced.

Scoppettone and Vinyard (1991) concluded that die-off of large blooms of *Aphanizomenon* has caused significant water quality impairment (e.g., low dissolved oxygen) that has resulted in fish kills. Although mass mortality of fish has been recorded over the observed history of the lake, its frequency appears to have increased (Perkins et al. 2000). Major incidents were recorded for 1995, 1996, and 1997; low dissolved oxygen appears to have been the direct cause of mortality in those years (Perkins et al. 2000). Under certain conditions, the bottom portion of the water column in the lake develops oxygen depletion, either no oxygen (anoxia) or lower than normal oxygen levels (hypoxia), and accumulates high concentrations of ammonia. Mixture of those bottom waters with the surface waters under the influence of changes in the weather may be a trigger for such mass mortality of fish (Vogel et al. 2001). Impaired water quality also might stress fish through high pH in surface waters resulting from high rates of photosynthesis, although exposures to the highest pH probably may be too brief to cause mortality (Saiki et al. 1999).

Water quality data collection in Upper Klamath Lake by various entities has been extensive, particularly in the past decade. Annual and seasonal trends of pH, total phosphorus, and chlorophyll *a* data collected at various locations in the lake as reported by ODEQ (2002) are presented in Figure E3.3-2. Total phosphorus concentrations in the lake and its outflow to the Klamath River can exceed 300 µg/L. This substantially exceeds the total phosphorus level of 200 µg/L established by the Organization for Economic Cooperation and Development (OECD) for classifying lakes as hypereutrophic (Philip Williams & Associates, 2001), and also substantially exceeds the 50 µg/L threshold reported by Welch (1992) for nutrient enrichment impairment of rivers and streams. Algal productivity is also very high, with chlorophyll *a* concentrations in excess of 200 µg/L frequently observed in the summer months, exceeding the peak chlorophyll *a* level of 75 µg/L established by OECD for classifying lakes as hypereutrophic

(Philip Williams & Associates, 2001), and the 15 µg/L threshold established by ODEQ for algae-related impairment of rivers and streams (OAR 340-041-0150).

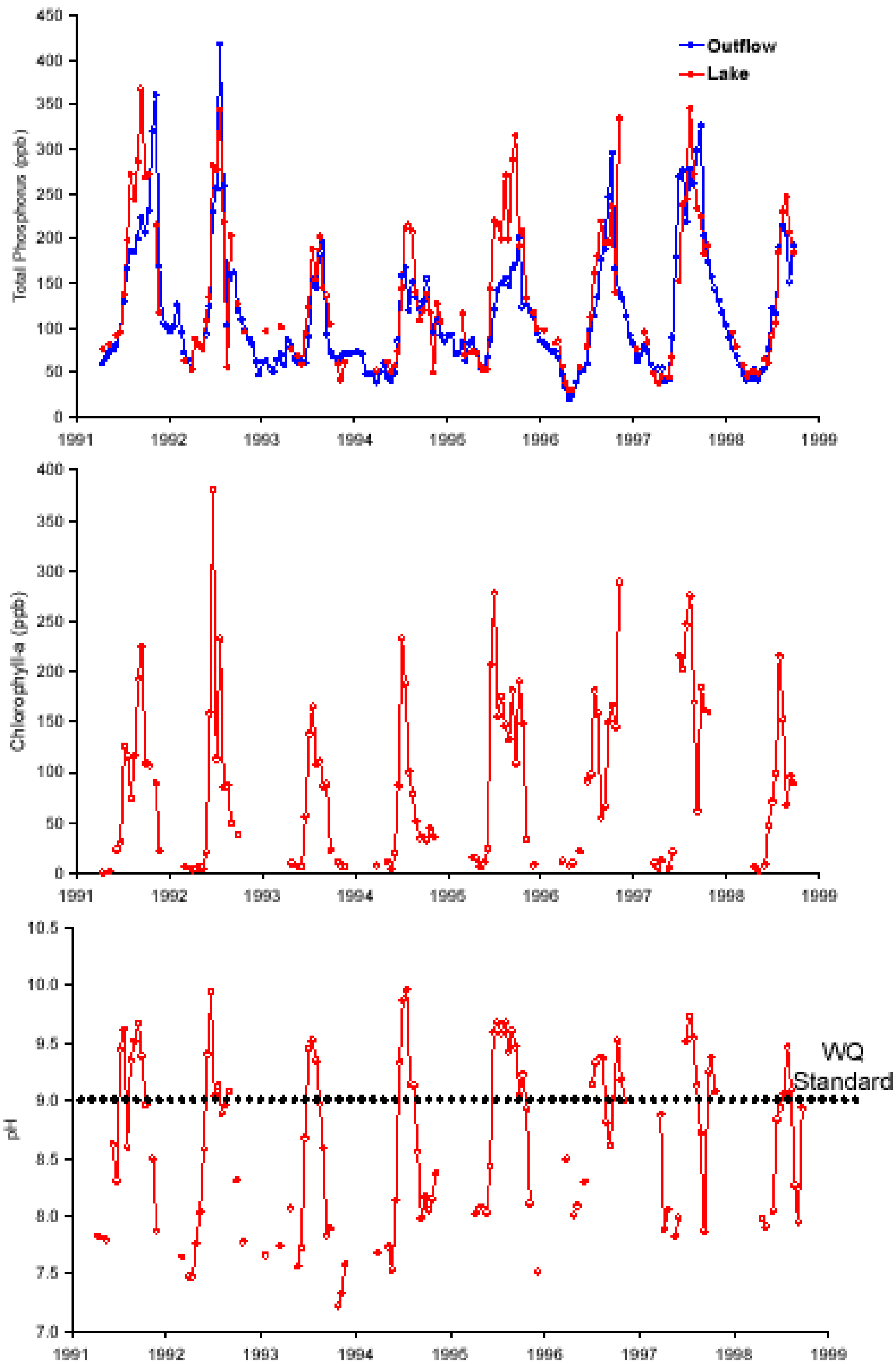


Figure E3.3-2. Observed total phosphorus, chlorophyll *a,* and pH values during 1991-1999 (reproduced from ODEQ, 2002).

Total phosphorus in Upper Klamath Lake tends to rise during spring and remains elevated through summer (Figure E3.3-3). ODEQ (2002) reports that the spring rise in total phosphorus results mainly from increases in phosphorus loading during spring runoff events from sources external to the lake. ODEQ (2002) reports that the continued high outflow rates of total phosphorus in summer is internally loaded to lake waters from nutrient rich sediments and algal bloom die-offs. An important mechanism for the release of phosphorus in shallow productive lakes is photosynthetically elevated pH, which solubilizes particulate-bound phosphorus in both suspended and bottom sediments (Welch, 1992; Jacoby et al. 1982). ODEQ reports that, on an average annual basis, external sources make up 39 percent and internal sources make up 61 percent of the total phosphorus load.

Upper Klamath Lake is also a seasonally significant source of nitrogen (Kann and Walker, 2001; ODEQ, 2001). The primary source for this nitrogen loading is from nitrogen fixation by *Aphanizomenon*. As a consequence of algal nitrogen fixation, ODEQ (2002) reports that the average outflow total nitrogen load was about 3.5 times the inflow load in 1992-1999. Another potential source is the mobilization of inorganic nitrogen from lake sediments during anaerobic bacterial decomposition.

Summertime pH values typically exceed 9.5 and periodically exceed 10.0 (Kann and Walker, 1999). Water temperatures in the lake can approach 30^{o}C near the surface, and temperatures of 22^{o}C to 24^{o}C are common in the upper 3 to 6 feet of the water column. At the same time, dissolved oxygen concentrations are often supersaturated in the upper part of the water column, but concentrations of less than 2.0 mg/L can occur near the bottom (Martin and Saiki, 1999).

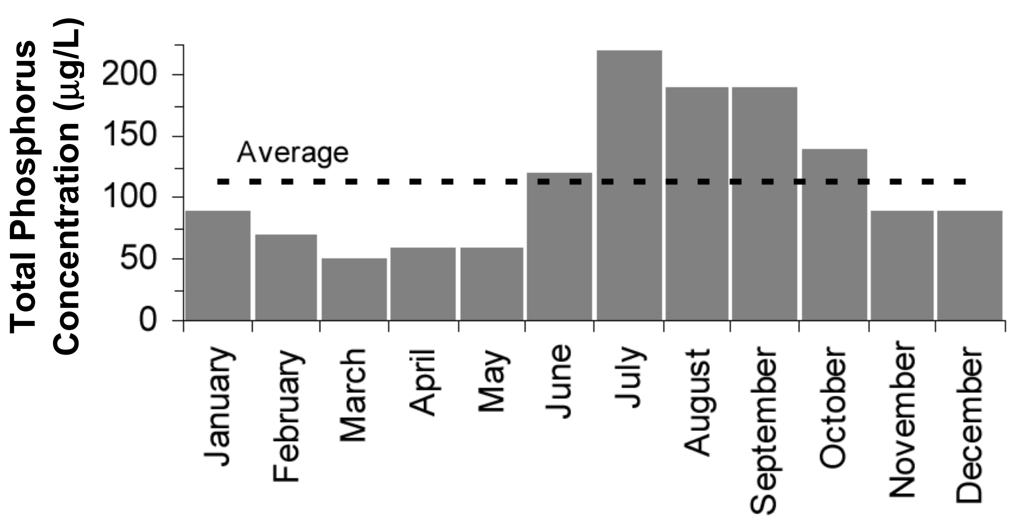


Figure E3.3-3. Upper Klamath Lake mean total phosphorus concentrations (reproduced from ODEQ, 2001, based on data of Kann and Walker, 2001).

E3.3.2 Lake Ewauna/Keno Reservoir

The driving force influencing water quality in the Project area is the quality of water entering the Project from Upper Klamath Lake and Klamath Straits Drain. Water entering Lake Ewauna from Link River carries a high load of organic nitrogen and other organic matter and is well seeded with algae, as evidenced by an average chlorophyll *a* concentration greater than 50 µg/L. The abundant algae delivered from Upper Klamath Lake continue to grow in Lake Ewauna and achieve chlorophyll *a* concentrations that average between 20 and 40 µg/L, and peak near 300 µg/L. The respiration demands of such abundant algal production combine with BOD to consume much of the oxygen in the water. Although sediment oxygen demand contributes to the oxygen depletion, recent work indicates that sediment oxygen demand in Lake Ewauna is not unusually high (in the range of 0.5 to 3.0 grams per square meter per day [g/m^2/day]) and that BOD demand in the water is the major cause of dissolved oxygen depletion in Lake Ewauna (see the Water Resources FTR, Section 9.0). There is sufficient oxygen demand to result in complete anoxia during certain periods.

The entire Klamath River system is high in phosphorus, including the tributary streams, with median total phosphorus concentration (0.21 mg/L) well above values commonly considered to indicate a eutrophic system (0.08 mg/L; Wetzel, 2001, p. 283), but water entering the reach from Link River is relatively low in phosphorus compared to Lake Ewauna. Klamath Straits Drain, however, provides phosphorus in abundance (median total phosphorus = 0.43 mg/L). The contribution of the Klamath Straits Drain to the Klamath River can be observed as a noticeable increase in total phosphorus concentration in Keno reservoir below Klamath Straits Drain. The concentration of nitrogen in the Klamath system (median = 1.3 mg/L) is lower than that generally considered characteristic of eutrophic systems (1.8 mg/L).

The ratio of total nitrogen to total phosphorus in the Klamath River system is below 7 (median = 6.6). The ratio of nitrogen to phosphorus in algal cells (Redfield ratio) is relatively constant at about 7:1 by weight. Reference to this ratio has been used as an approximate indicator of relative nutrient limitation of phytoplankton in lakes. A ratio of N:P more than about 10:1 (by weight) is generally considered to indicate phosphorus limitation. The median N:P ratio in the Project area equals 6.6:1. Only about 20 percent of all values are greater than 10:1. This condition holds from Link dam to Iron Gate dam, which suggests that phytoplankton growth in the Klamath River is strongly nitrogen-limited. Abundant phosphorus, coupled with limited nitrogen and warm water, provides advantageous conditions for nitrogen-fixing species, so it is not surprising that the Project reservoirs support blooms of the nitrogen-fixing cyanophyte *Aphanizomenon flos-aquae.*

Lake Ewauna and Keno reservoir are shallow and exposed to the effects of wind; therefore, they do not experience stable thermal stratification, although periods of calm during warm weather may result in short-term stratification. The slow movement of water downstream through the reach simulates a large flow-through reactor and results in longitudinal rather than vertical gradients of constituents. This condition is illustrated in Figure E3.3-4. As water flows through the reservoir (moving from right to left on the figure), temperature (top panel) increases from Link River (RM 253) to Miller Island (RM 246), decreases slightly to RM 241 upstream of Klamath Straits Drain, increases to a maximum at RM 238 downstream of Klamath Straits Drain, and then decreases to RM 235 (Highway 66 at Keno).

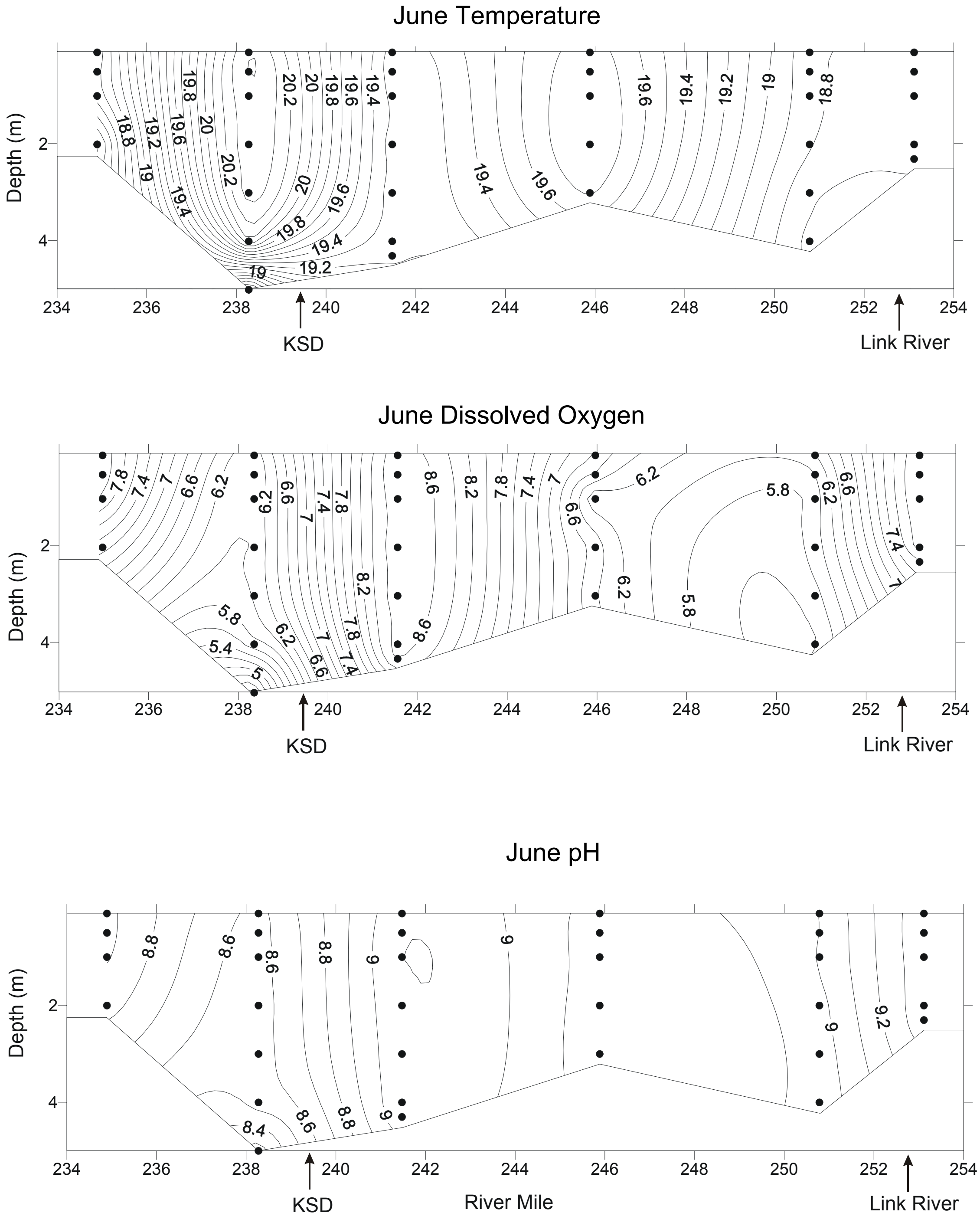


Figure E3.3-4. Isopleth diagram for water temperature, dissolved oxygen, and pH in Lake Ewauna and Keno reservoir for June 2002. Based on profile data collected by USBR at the following sites: KR25312, Link River at Mouth; KR25173, Lake Ewauna at railroad bridge drawspan; KR24589, Klamath River at Miller Island boat ramp; KR24248, Klamath River upstream of Klamath Strait Drain; KR23828, Klamath River south of Hill 4315; and KR23490, Klamath River at Keno (Highway 66 bridge).

Dissolved oxygen also undergoes a longitudinal gradient, increasing from Link River to RM 241, then decreasing to a minimum at RM 238 downstream of Klamath Straits Drain, before increasing again toward RM 235. This longitudinal gradient persists throughout the year, although it can be modified with a vertical component during warm weather, as illustrated in Figure E3.3-5.

The longitudinal changes, combined with inflow of water high in nutrients and dissolved solids from Klamath Straits Drain (Table E3.3-3), cause the water quality at site KR23828 in Keno reservoir downstream from Klamath Straits Drain to be different from water quality at sites upstream. It is more similar to the Klamath River at Keno (KR23490), at Keno dam (KR23360), and below Keno dam (KR23334). Site KR23828 has higher specific conductance, total phosphorus, and orthophosphate phosphorus, more frequent low (less than -100 mv) oxidation reduction potential[11] (ORP) values, and lower BOD, chlorophyll, and nitrate nitrogen than sites upstream.

Table E3.3-3. Descriptive statistics for Klamath Straits Drain (Site KS01).

Variable	**N**	**Mean**	**Minimum**	**Median**	**Maximum**
NH_3	28	0.558	0.070	0.410	2.470
NO_3	23	0.602	0.060	0.370	2.290
PO_4	28	0.350	0.050	0.360	0.680
PT	28	0.470	0.100	0.425	0.900
SPC	63	559	262	565	1046

[11] Defined as the electric potential required to transfer electrons from one compound or element (the oxidant) to another compound (the reductant); used as a measure of the state of oxidation in water or sediments.

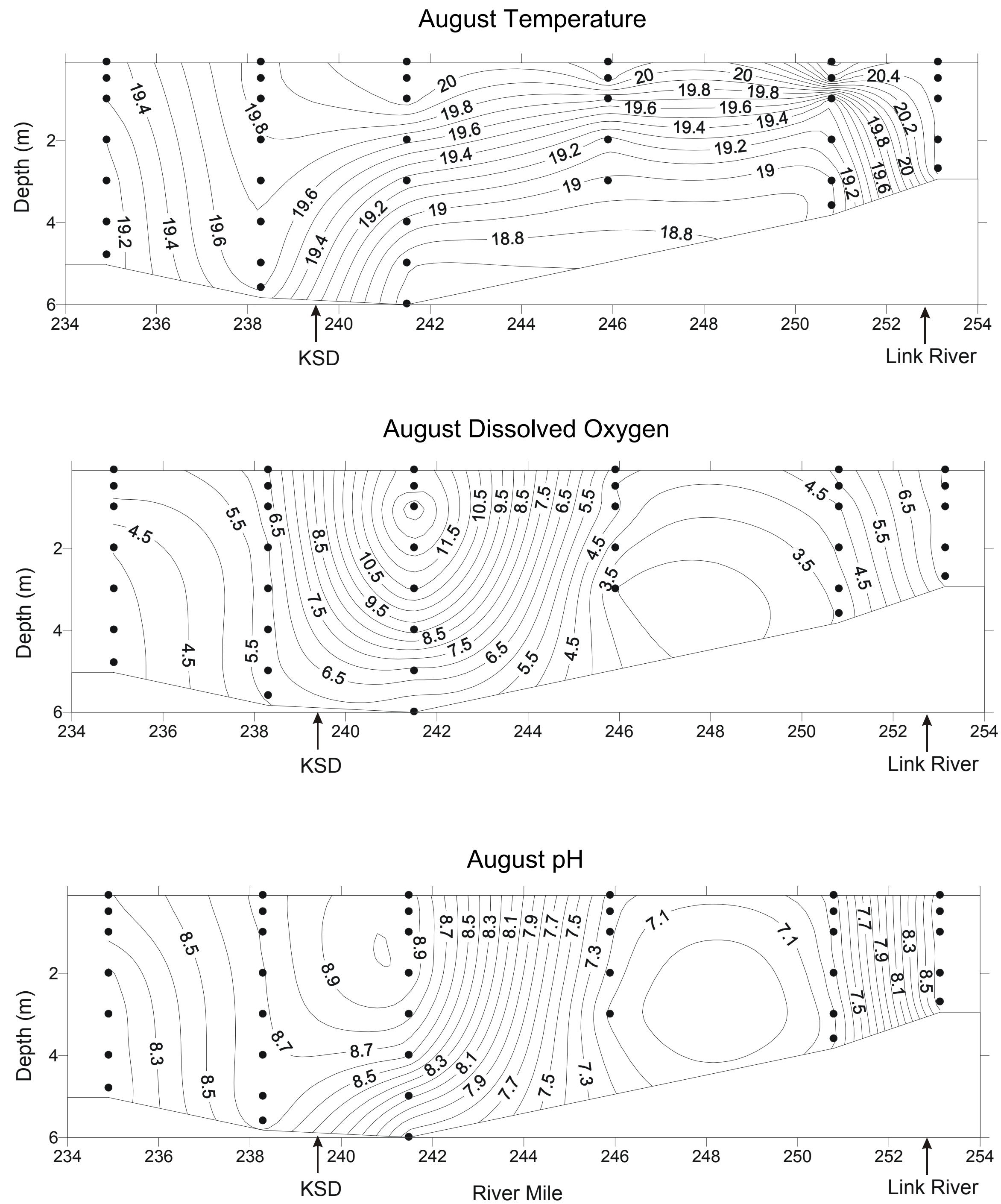


Figure E3.3-5. Isopleth diagram for water temperature, dissolved oxygen, and pH in Lake Ewauna and Keno reservoir for August 2002. Based on profile data collected by USBR at the following sites: KR25312, Link River at mouth; KR25173, Lake Ewauna at railroad bridge drawspan; KR24589, Klamath River at Miller Island boat ramp; KR24248, Klamath River upstream of Klamath Straits Drain; KR23828, Klamath River south of Hill 4315; and KR23490, Klamath River at Keno (Highway 66 bridge).

E3.3.3 River Reaches

This section includes the portion of the Project area from below Keno dam to Copco reservoir. J.C. Boyle reservoir is included in this discussion because the short residence time and shallow depth of this reservoir are more characteristic of a slow-moving river than a reservoir. Water quality measurements taken at the surface and near the bottom of J.C. Boyle reservoir near the dam show no significant difference in most constituents (Table E3.3-4). J.C. Boyle reservoir does not experience stable vertical stratification. However, a localized depression in the bottom topography of the reservoir near the dam permits a small pool of stagnant water to persist in the deepest portion of the reservoir. This may account for the difference in dissolved oxygen and ammonia nitrogen between near-surface and near-bottom measurements.

Table E3.3-4. Comparison water quality constituents measured at the surface (1 m) and bottom (7 m) of J.C. Boyle reservoir near the dam (KR22478).

Constituent	**P value (paired t test)**
Temperature	0.180
Dissolved Oxygen	0.001
Total Phosphorus (PT)	0.52
TKN	0.33
Orthophosphate (PO_4)	0.76
Nitrate (NO_3)	0.09
Ammonia (NH_3)	0.003

Several geomorphic characteristics of the Klamath River between Keno dam and Copco reservoir have consequences for water quality. From Keno dam to J.C. Boyle reservoir, the river is steep and fast-flowing, providing good mixing and aeration. The river flows more slowly through J.C. Boyle reservoir to J.C. Boyle dam, where much of the flow is diverted to the J.C. Boyle powerhouse to re-enter the main channel about 4 miles downstream. In this 4-mile bypass reach, significant inflow of groundwater (estimated at about 220 cfs) alters the quality of the river water. Some of these changes persist through the peaking reach and are evident in Copco and Iron Gate reservoirs.

The inflow of approximately 225 cfs of groundwater into the river between J.C. Boyle dam and the J.C. Boyle powerhouse (the bypass reach) enhances water quality in the peaking reach. In the summer, daily average water temperature decreases between Keno dam and Copco reservoir (Figure E3.3-6). Data from 2002 suggest that this is not an effect of the mode of power operations. Table E3.3-5 lists the difference in average water temperature for a 1-week period in 2002 during peaking operation and during steady flow conditions. There is a substantial decrease in water temperature between the outlet of J.C. Boyle dam (KR22460) and the Klamath River upstream of Shovel Creek (KR20642). There is relatively little difference between the outlet of J.C. Boyle dam and Keno dam (KR23334).

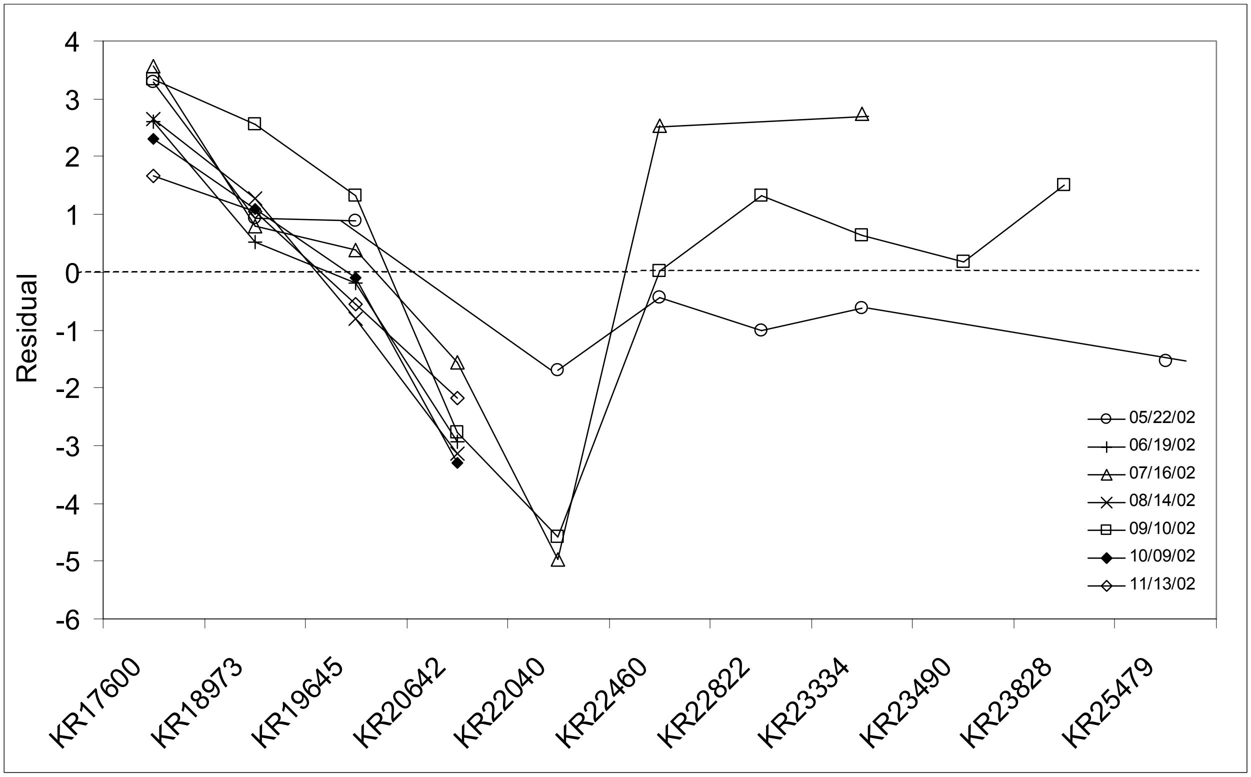


Figure E3.3-6. Spatial trends in water temperature residual in the Klamath River between Link dam and the Shasta River. The residual = Tx – T, where Tx is the temperature at site x on a particular day and T is the mean temperature of all sites for that day. Sites are shown in upstream order from left to right in the plot. KR25479 – Upper Klamath Lake at Fremont Bridge, KR23828 – Klamath River south of Hill 4315, KR23490 – Klamath River at Keno Bridge (Hwy. 66), KR23334 – Klamath River below Keno dam, KR22822 – Klamath River above J.C. Boyle reservoir, KR22460 – Klamath River below J.C. Boyle dam, KR22040 – Klamath River at J.C. Boyle bypass (bottom), KR20642 – Klamath River upstream of Shovel Creek, KR19645 – Klamath River at Copco dam outflow, KR18973 – Klamath River at Iron Gate dam outflow, KR17600 – Klamath River upstream of Shasta River.

Table E3.3-5. Change in average water temperature between sites in the Klamath River during peaking and nonpeaking operations. Sites include KR23334 – Klamath River below Keno dam, KR22460 – Klamath River below J.C. Boyle dam, and KR20642 – Klamath River upstream of Shovel Creek.

Site	**Peaking 9/11/02-9/18/02**	**Nonpeaking 9/25/02-10/02/02**
KR23334 – KR22460	0.43	0.64
KR22460 – KR20642	2.23	2.28

Figure 3.3-7 shows daily discharge measured at the USGS gauge below J.C. Boyle powerhouse for representative periods of peaking and nonpeaking operation. The relatively cold water flowing in the bypass reach, combined with the fluctuation in discharge from the J.C. Boyle powerhouse during normal operation, affects the water temperature regime in the Klamath River

below the powerhouse (peaking reach). The diurnal pattern of water temperature variation is similar to sites not affected by peaking operation, but the range of variation is larger (Figure E3.3-8, upper plot). The range of daily water temperature variation below the powerhouse is greatly reduced, relative to unaffected sites, under conditions of constant daily discharge (Figure E3.3-8, lower plot). This reduction in range is largely the result of warmer minimum daily water temperatures because the influence of cool groundwater is reduced.

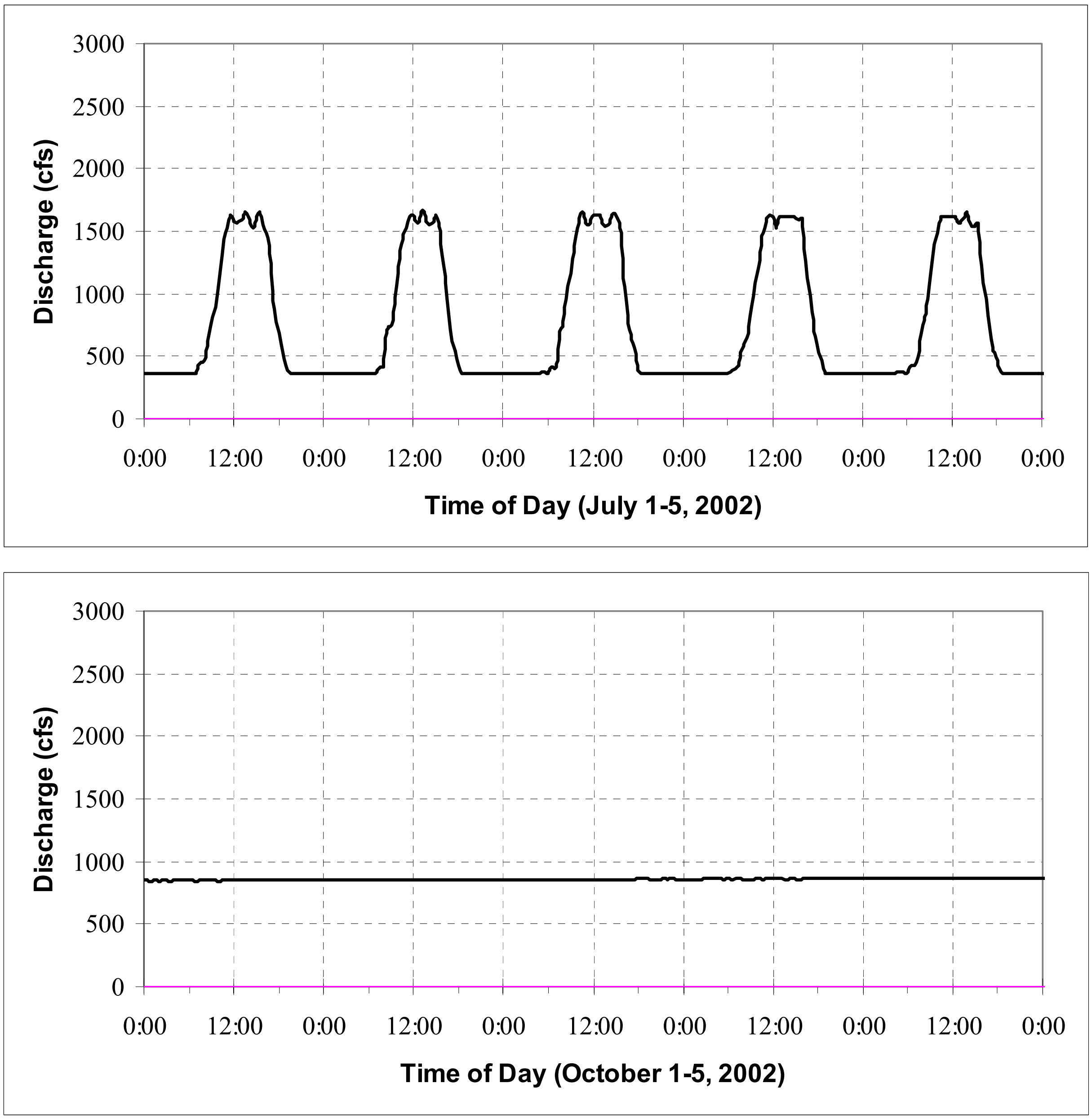


Figure 3.3-7. Discharge measured at the USGS gauge below the J.C. Boyle powerhouse in 2002 during peaking operation (top) and during nonpeaking flow (bottom).

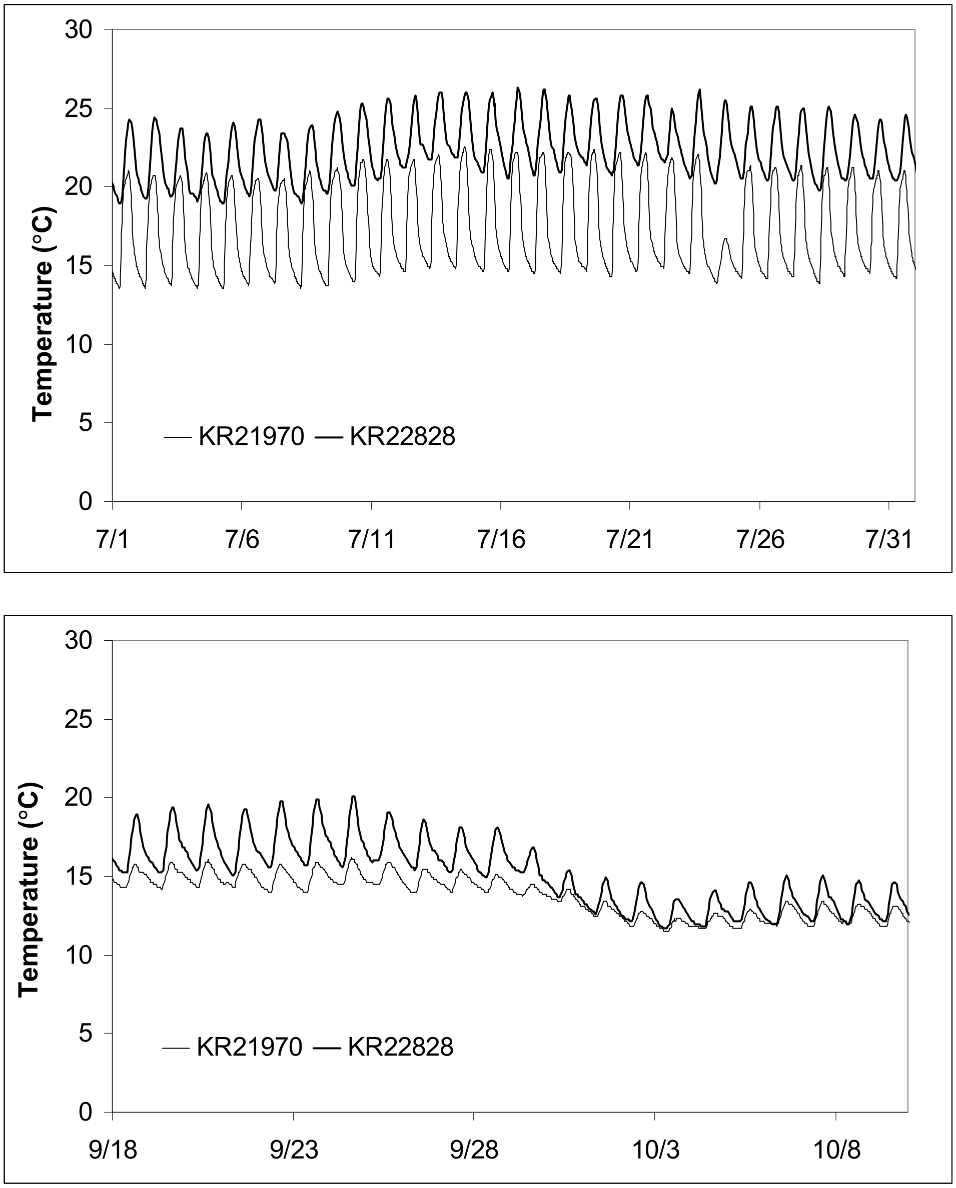


Figure 3.3-8. Water temperatures measured above and below the J.C. Boyle powerhouse during peaking operation (top) and during nonpeaking flow (bottom) during 2002. KR22828 (upper curve in both plots) – Klamath River above J.C. Boyle reservoir, KR21970 (lower curve) – Klamath River at the USGS gauge below J.C. Boyle dam.

The interaction of varying discharge and travel time affects the diurnal water temperature pattern at the downstream end of the J.C. Boyle peaking reach. Figure E3.3-9 shows the diurnal water temperature cycle measured in the peaking reach just upstream from Copco reservoir (KR20300, angler access 2) during peaking operation (July 1-5) and during constant daily discharge (October 1-5). The “notch” in the July curve between approximately 1:00 p.m. and 6:00 p.m. marks the arrival at the site of cooler water leaving the J.C. Boyle bypass reach when flow through the power turbines is shut off. That pattern is absent from the site during constant discharge operations in October. However, by October, temperatures in the river are similar to those in the bypass reach, which may make such a pattern more difficult to discern.

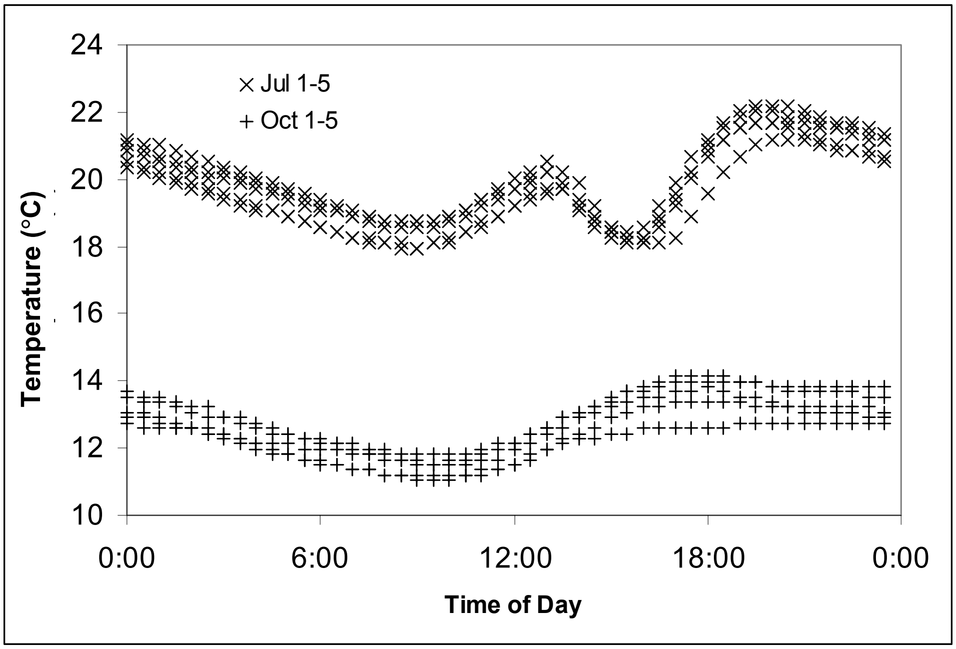


Figure E3.3-9. Water temperatures measured in the Klamath River above Shovel Creek (KR20645) during periods of peaking operation (July, top) and during nonpeaking discharge (October, bottom) in 2002.

Median total phosphorus concentration is lower in the J.C. Boyle bypass reach and at sites downstream than at sites upstream (Figure E3.3-10). Orthophosphate phosphorus concentration, although slightly lower in the J.C. Boyle bypass reach, is not markedly different entering Copco reservoir than it is below Keno dam (Figure E3.3-10). The increase in orthophosphate phosphorus observed downstream of Klamath Straits Drain appears to persist until Copco reservoir.

Nitrogen undergoes somewhat more complex changes (Figure E3.3-11). Median concentrations of TKN are high in Lake Ewauna and decrease downstream through the system. Ammonia nitrogen follows a similar pattern, with the notable exception of Copco reservoir (KR19874). The pattern of median nitrate nitrogen concentration is approximately the converse of TKN and ammonia nitrogen. Concentrations are quite low in Lake Ewauna above Klamath Straits Drain and then increase to maximum in J.C. Boyle reservoir (KR22478), returning to relatively low values below Iron Gate dam.

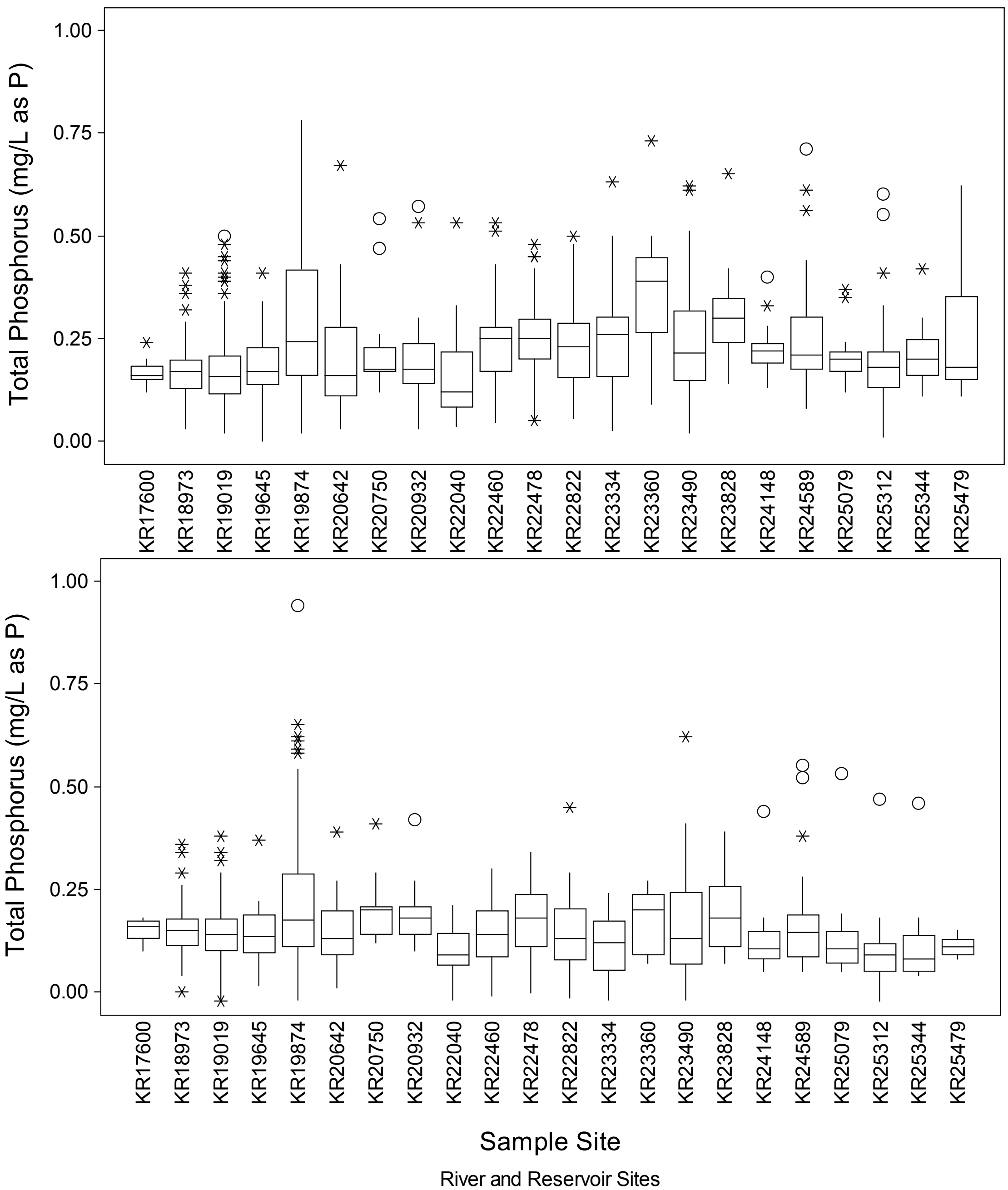


Figure E3.3-10. Box plot showing the distribution by site of total phosphorus (top plot) and orthophosphate phosphorus (bottom plot) values measured in the Project area during 2000-2003. KR17600 – Klamath River upstream of Shasta River, KR18973 – Iron Gate dam outflow, KR19019 – Iron Gate reservoir near Hornbrook, KR19645 – Copco dam outflow, KR19874 – Copco Lake near Copco, KR20642 – Klamath River upstream of Shovel Creek, KR20750 – Klamath River above Copco, KR20932 – Klamath River near stateline, KR22040 – J.C. Boyle bypass (bottom), KR22460 – Klamath River below J.C. Boyle dam, KR22478 – J.C. Boyle reservoir at log boom, KR22822 – Klamath River above J.C. Boyle reservoir, KR23334 – Klamath River below Keno dam, KR23360 – Keno reservoir at log boom, KR23490 – Klamath River at Keno Bridge (Hwy. 66), KR23828 – Klamath River directly south of Hill 4315, KR24148 – Klamath River upstream of Klamath Straits Drain, KR24589 – Klamath River at Miller Island boat ramp, KR25079 – Klamath River at South-Side Bypass bridge, KR25312 – Link River at mouth, KR25344 – Link River near powerhouse, KR25479 – Upper Klamath Lake at Fremont St. Bridge.

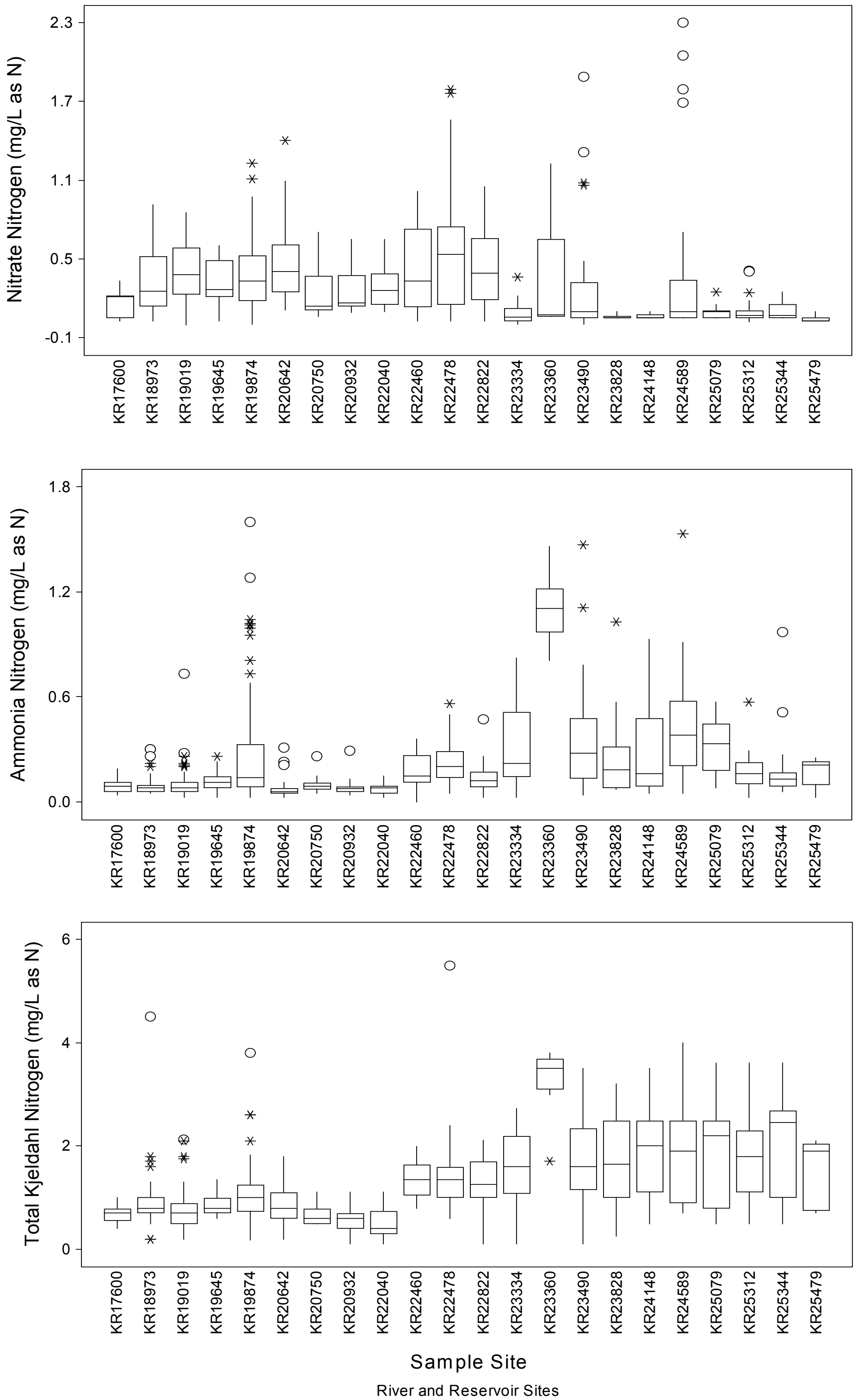


Figure E3.3-11. Box plot showing the distribution by site of nitrogen values measured in the Project area during 2000-2003.

The spatial changes in nitrogen and phosphorus are illustrated for one day, June 18, 2002, in Figure 3.3-12. Between the site below Keno dam (RM 233) and upstream of J.C. Boyle reservoir (RM 228), nitrate nitrogen (NO_3) concentration increases, TKN and BOD concentration decrease, and ammonia nitrogen (NH_3) concentration remains more or less constant, resulting in a net increase in inorganic nitrogen. Phosphorus concentration increases below Klamath Straits Drain (RM 240) and stays fairly constant through the rest of the Project area. These changes suggest that phosphorus is present in the system in abundance relative to the needs of aquatic plants and that decomposition of organic matter and nitrification of ammonia nitrogen are actively occurring in the Klamath River between Keno dam and J.C. Boyle reservoir. This change in nutrient availability does not appear to be reflected in the abundance of phytoplankton, because the chlorophyll *a* concentration decreases markedly below Keno dam. It is more likely, however, that the apparent decrease in chlorophyll represents a shift from the free-living phytoplankton dominant in the reservoirs to attached forms that are not captured with the current sampling protocol. By RM 176, upstream from the Shasta River, total nitrogen (NO_3 + TKN) has decreased to less than half the concentration found in Lake Ewauna (Figure 3.3-13).

Temperature and dissolved oxygen in the Klamath River between Keno dam and Copco reservoir are generally in equilibrium with the ambient conditions as a result of the free-flowing nature of the river in this area. Dissolved oxygen in the river is near saturation because there is ample opportunity for re-aeration. The Klamath River cools slightly as it flows downstream, from Keno dam to J.C. Boyle reservoir, and considerably from J.C. Boyle dam to Copco reservoir—the result of groundwater discharge in the J.C. Boyle bypass reach.

The operation of J.C. Boyle dam in peaking mode influences the temperature in the Klamath River below the dam through the interaction of cool water flowing constantly from the bypass reach and warm water flowing intermittently from the power plant. Peaking operation tends to increase the range of the diurnal temperature cycle near the upstream end of the peaking reach, and produces a more complex daily temperature cycle in the river near the downstream end of the peaking reach.

The high concentration of algal nutrients supplied from Upper Klamath Lake and Keno reservoir to the Klamath River in the Project area leads to changes in pH through the action of algal photosynthesis. Algal uptake of carbon dioxide results in high pH during the day, while respiration by algae and other organisms at night tends to depress the pH. This creates large diurnal range in pH values. This is especially prevalent in the surface waters of the Project reservoirs and, to a lesser extent, in the free-flowing sections of the river. The deeper water in the Project reservoir outside the zone of active photosynthesis, and dominated by respiration processes, does not exhibit high pH values.

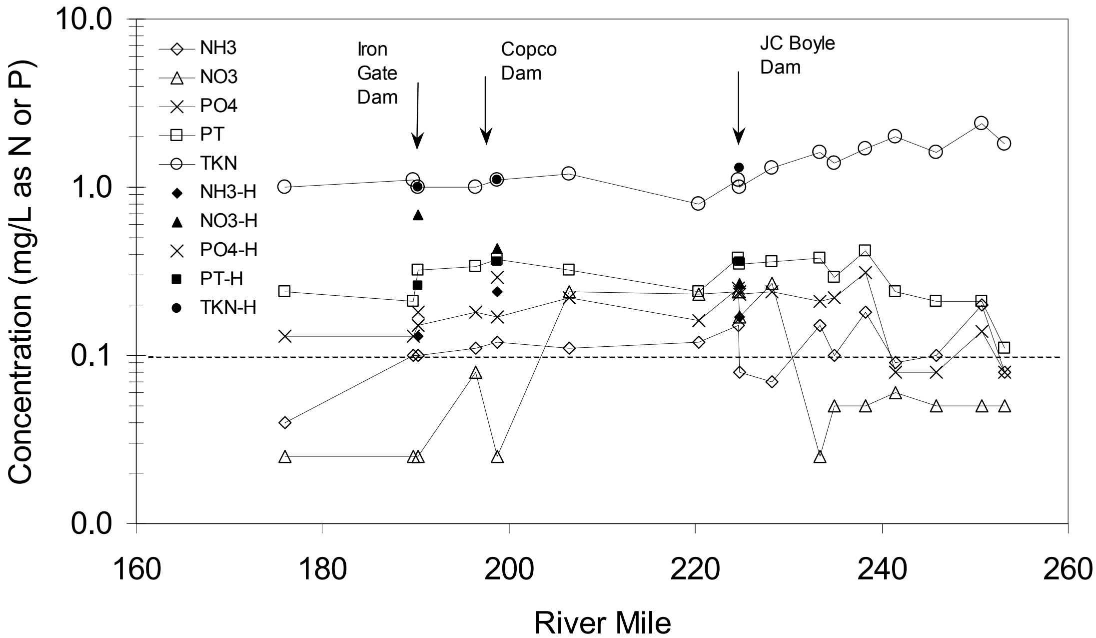


Figure E3.3-12. Concentration of nutrients measured at various sites in the Project area, June 18, 2002. NO_3 = nitrate nitrogen, NH_3 = ammonia nitrogen, TKN = total Kjeldahl nitrogen, PT = total phosphorus, PO_4 = orthophosphate phosphorus (H suffix designates hypolimnetic values). The horizontal dashed line represents the method reporting limit for ammonia and nitrate. Values below this line are considered to be estimated values.

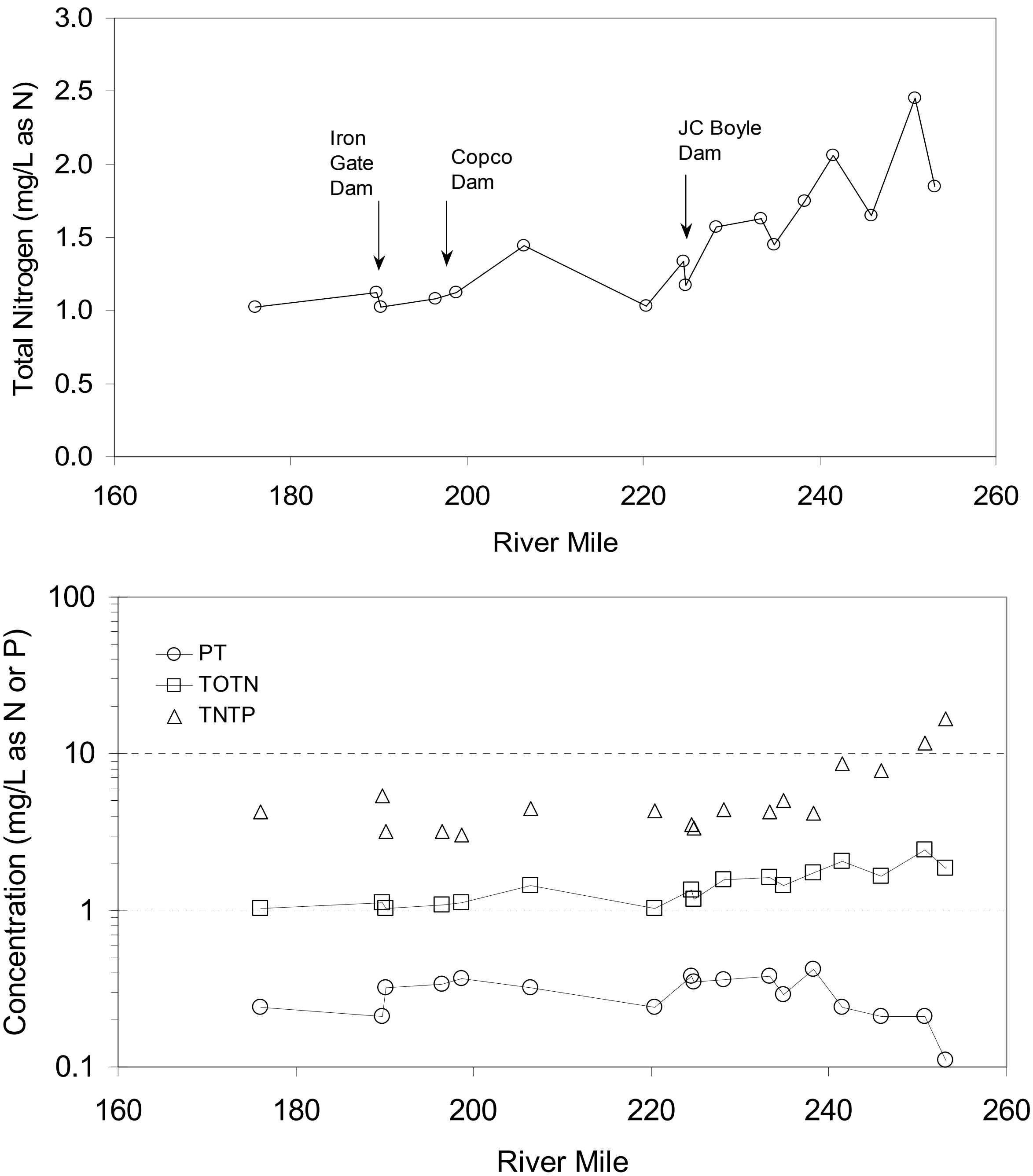


Figure E3.3-13. Concentration of nutrients measured at various sites in the Project area, June 18, 2002.

E3.3.4 Reservoirs

Water quality processes in Copco and Iron Gate reservoirs are dominated by the thermal stratification that occurs annually in both reservoirs (Figures E3.3-14). Although these two reservoirs differ in shape, size, and mode of operation, the pattern of stratification in each is similar. In the spring as the surface waters warm, a density gradient with depth is established. When wind energy is no longer sufficient to overcome this gradient, the temperature of the surface water diverges from the deeper water and thermal stratification occurs. This usually happens in March. The surface waters continue to warm until reaching a maximum, usually in late August, at which time they begin to cool. As the surface waters cool, the density gradient lessens and wind energy is sufficient to mix the water to deeper depths until, usually in mid-November, the reservoir becomes isothermal. This is illustrated in Figure E3.3-15, which shows hourly water temperature data from several depths in Copco and Iron Gate reservoirs.

Superimposed on this overall pattern are shorter duration patterns. As indicated in Figure E3.3-15, the surfaces of Copco and Iron Gate reservoirs are subject to diurnal water temperature changes as a result of solar heating and variation on the order of several days in response to changing weather patterns. Diurnal variations are not evident in the deeper waters of these reservoirs because they are isolated by the density gradient.

There is, however, a definite, approximately daily, temperature fluctuation at 40 feet and 60 feet in depth. This reflects the effect of peaking operation of J.C. Boyle and Copco reservoirs. As a result of either the conservation of momentum in the water column when power generation ceases or the influence of rapid changes in the flow entering the reservoir, or a combination of both, an internal wave (seiche) is created at the depth where the temperature gradient is most intense. As this wave passes the stationary temperature data logger, it causes a fluctuation in the recorded temperature. The seiche also induces some mixing at depth in the reservoirs, resulting in the gradual warming of the deeper layers. As shown in Figure E3.3-15, this warming in the deeper water continues even as the water at shallower depths is cooling rapidly.

Thermal stratification has a number of effects. It isolates the deep water (hypolimnion) from the surface, preventing re-aeration. Consequently, respiration by organisms in the hypolimnion, such as bacteria decomposing organic matter, can deplete the oxygen in the hypolimnion and lead to the release of nitrogen and phosphorus from the sediment. The thermal gradient also controls the depth to which inflowing water moves as it enters the reservoir. Cooler water will sink to a depth that matches its density while warmer water will tend to move across the surface of the reservoir.

Both Copco and Iron Gate reservoirs exhibit the characteristics of productive, stratified lakes. Water temperatures in the hypolimnion are lower than in the epilimnion (surface), dissolved oxygen concentration in the hypolimnion is lower than in the epilimnion, the pH is lower in the hypolimnion than the epilimnion, and chlorophyll *a* concentration is much higher in the epilimnion than in the hypolimnion (Table E3.3-6). However, Copco reservoir has a much higher concentration of ammonia (as N), orthophosphate (as P), total phosphorus, and TKN in the hypolimnion than in the epilimnion; in Iron Gate reservoir those constituents are the same concentration in both epilimnion and hypolimnion, or even lower in the hypolimnion than the epilimnion.

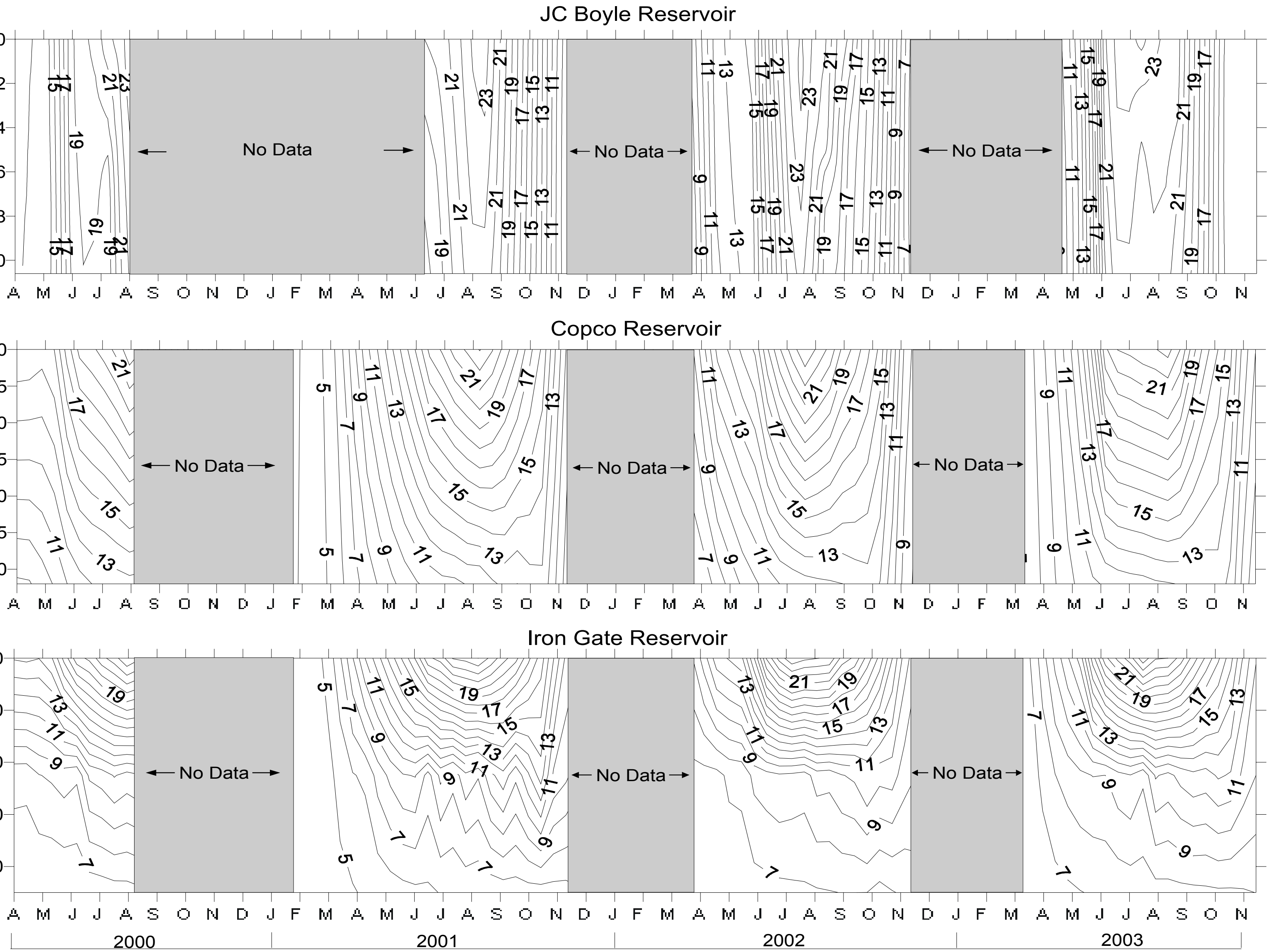


Figure E3.3-14. Isopleth diagram of water temperature for J.C. Boyle, Copco, and Iron Gate reservoirs for 2000 through 2003.

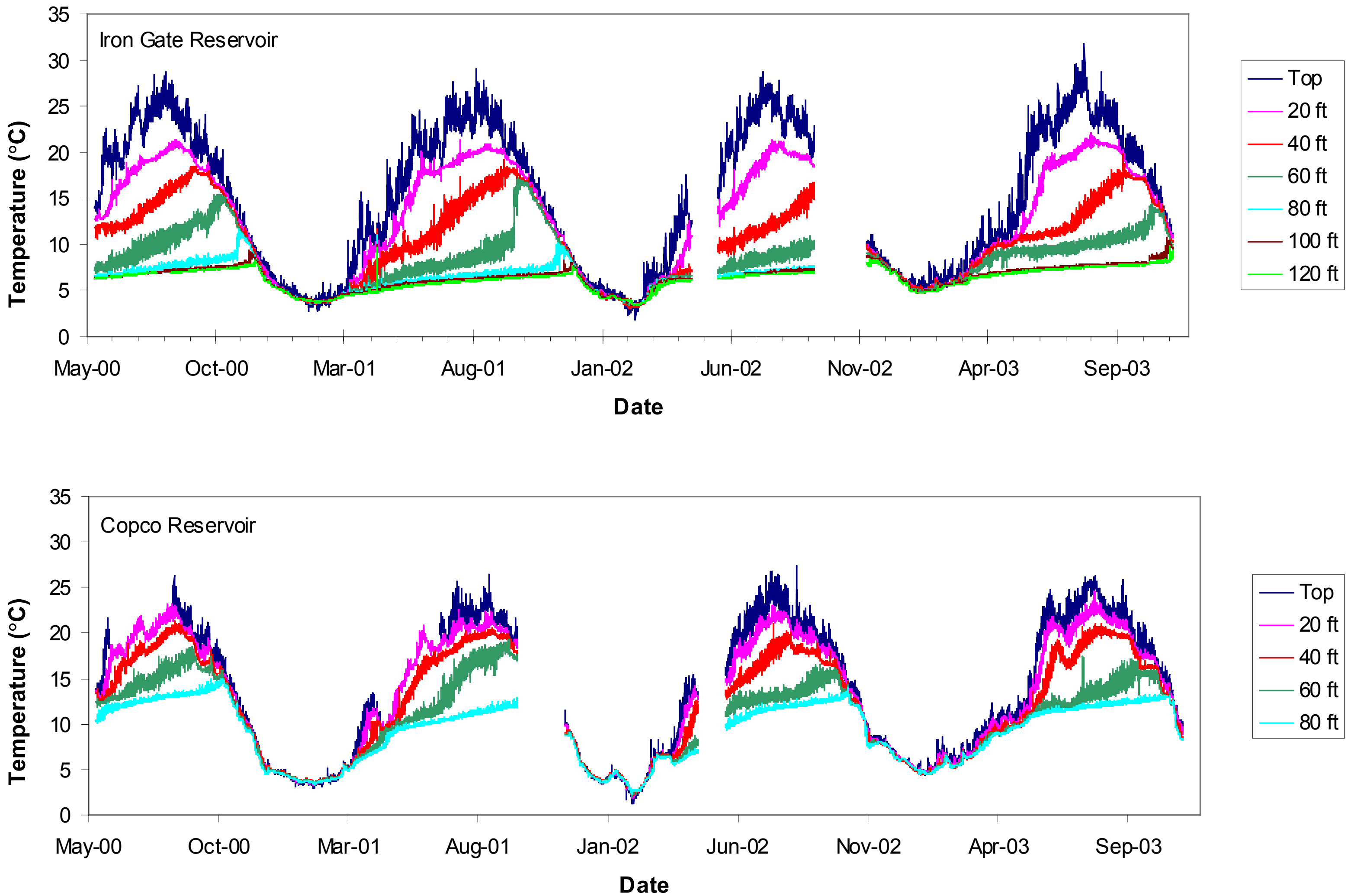


Figure E3.3-15. Hourly water temperature measurements from Copco (top) and Iron Gate (bottom) reservoirs.

Table E3.3-6. Comparison of means of monthly water quality constituents in Copco and Iron Gate reservoirs.

	Copco Reservoir		**Iron Gate Reservoir**	
Constituent	**Epilimnion**	**Hypolimnion**	**Epilimnion**	**Hypolimnion**
Alkalinity (mg/L)	68.6	72.7	69.9	66.2
BOD (mg/L)	5.8	4.4	4.1	2.2
Chlorophyll *a* (µg/L)	11.7	5.2	11.9	6.4
Conductivity (µS/cm)	140	135	139	127
Dissolved oxygen (mg/L)	9.2	3.1	8.8	4.1
Ammonia-N (mg/L)	0.12	0.59	0.097	0.11
Nitrate-N (mg/L)	0.38	0.4	0.27	0.5
ORP (mv)	155	118	159	203
pH	8.2	7.3	8.1	7.2
PO_4-P (mg/L)	0.18	0.37	0.15	0.18
Total P (mg/L)	0.26	0.47	0.295	0.2
Redox (mv)	155	116	160	203
Specific Conductance (µS/cm)	166	174	163	175
Temperature (°C)	15.5	10.4	15.6	7.2
TKN (mg/L)	1.12	1.27	0.89	0.57

The volume of Iron Gate reservoir below the depth of mixing (approximately 10 m) is nearly three times as great as the comparable volume of Copco reservoir (28 million cubic meters versus 11 million cubic meters). Consequently, Copco reservoir is more likely to become anoxic, as indicated in Figure E3.3-16. The hypolimnion of Copco reservoir is essentially lacking in dissolved oxygen (< 2 mg/L) beginning in early May most years and extending until mid-October, while the hypolimnion in Iron Gate reservoir does not reach that condition until late May, June, or even mid-July.

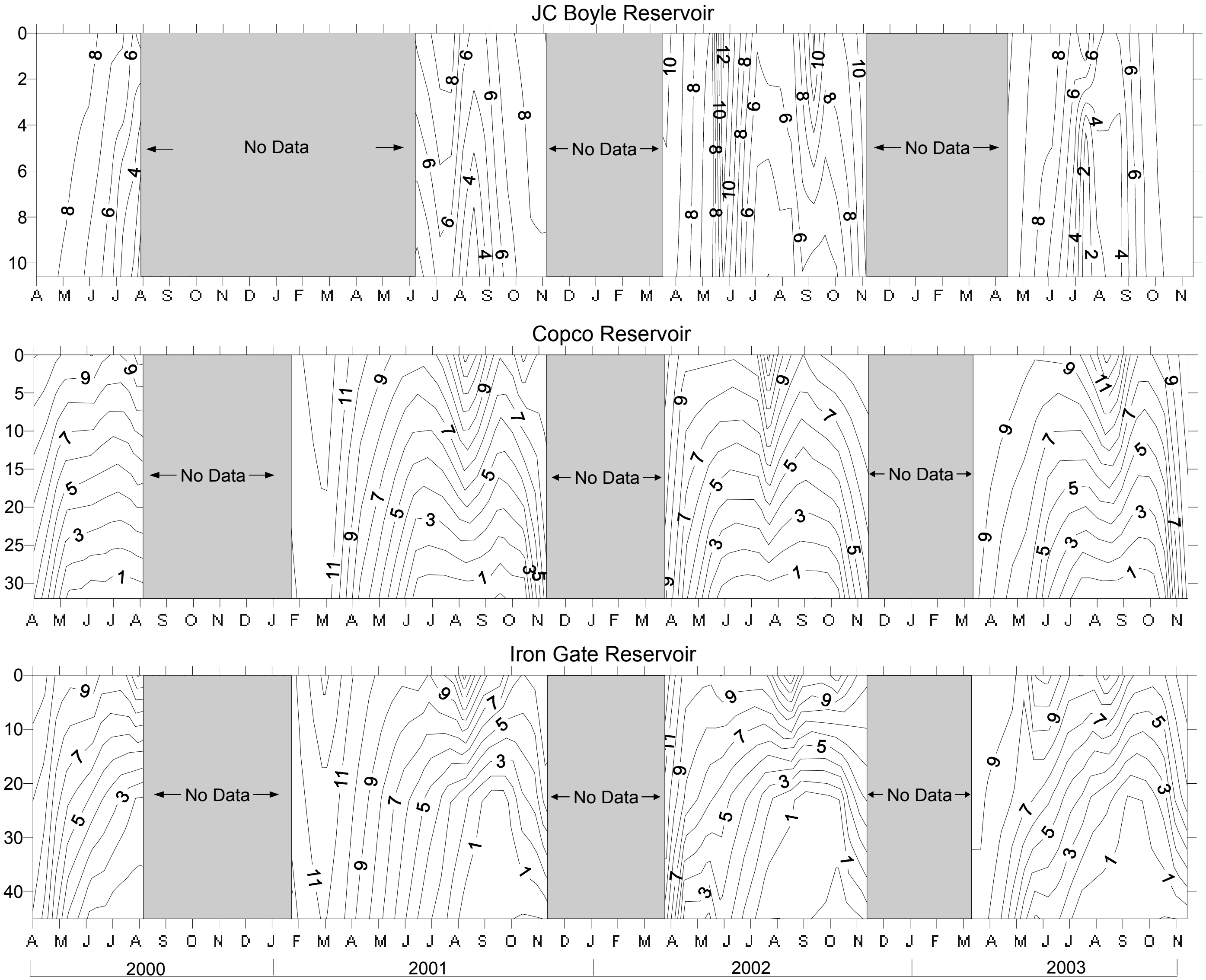


Figure E3.3-16. Isopleth diagram of dissolved oxygen for J.C. Boyle, Copco, and Iron Gate reservoirs for 2000-2003.

Extended periods of anoxia promote conditions that result in the reduction of NO_3 to NH_3 and can lower ORP to the point that phosphorus is released from the sediment. Such conditions occur regularly in Copco reservoir, especially in August and September, but rarely in Iron Gate reservoir (Figure E3.3-17). The differences in ORP in the reservoirs are reflected in nutrient concentrations in the hypolimnion: PO_4 and NH_3 are noticeably more abundant in the hypolimnion of Copco reservoir than in Iron Gate reservoir (Figure E3.3-18).

The depth of the discharge from a reservoir can have a strong effect on conditions in the reservoir and in the river below the dam. A deep discharge from a stratified reservoir can discharge water that is very low in oxygen to the detriment of downstream organisms. The power plant intakes for both Copco and Iron Gate reservoirs are fairly shallow, and they draw most of their water from the epilimnion and metalimnion—the region of thermal gradient in the reservoir. In Iron Gate reservoir, the power intake is at about a 30-foot depth. While the intake draws water from a range of depths, the temperature of the water leaving the reservoir is similar to the temperature at a depth of 10 feet within the reservoir (Figure E3.3-19). Copco reservoir also discharges from a depth that lies within the epilimnion.

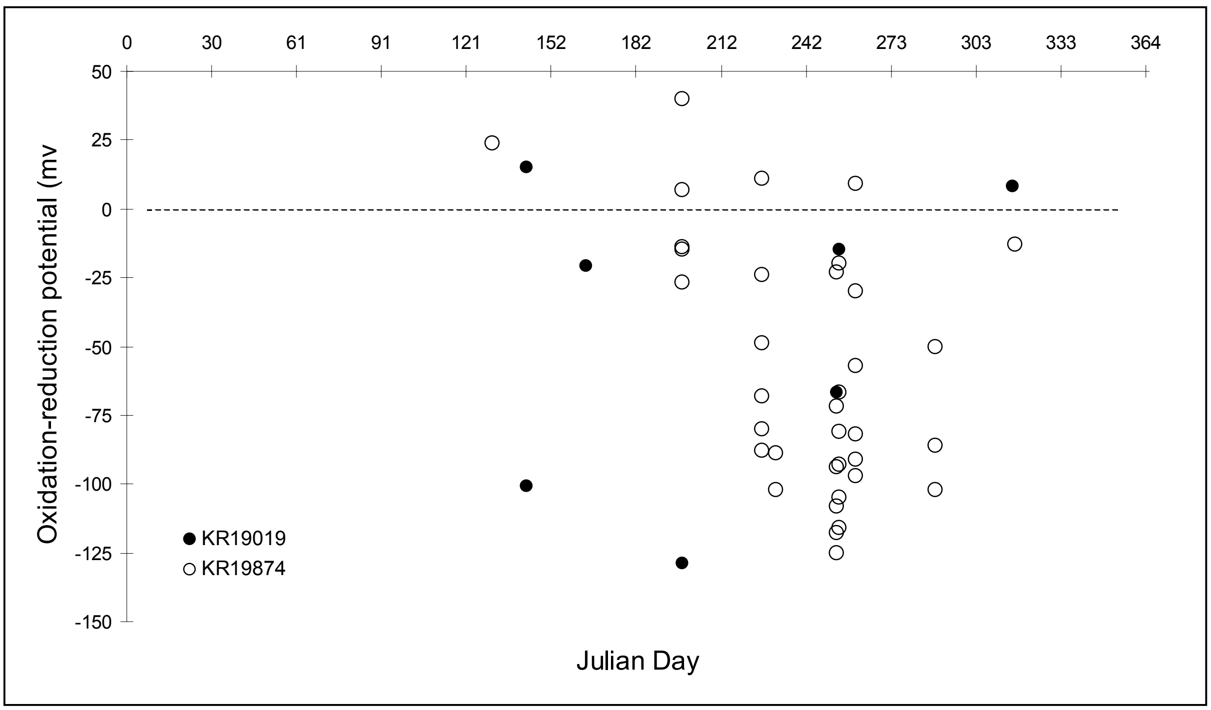
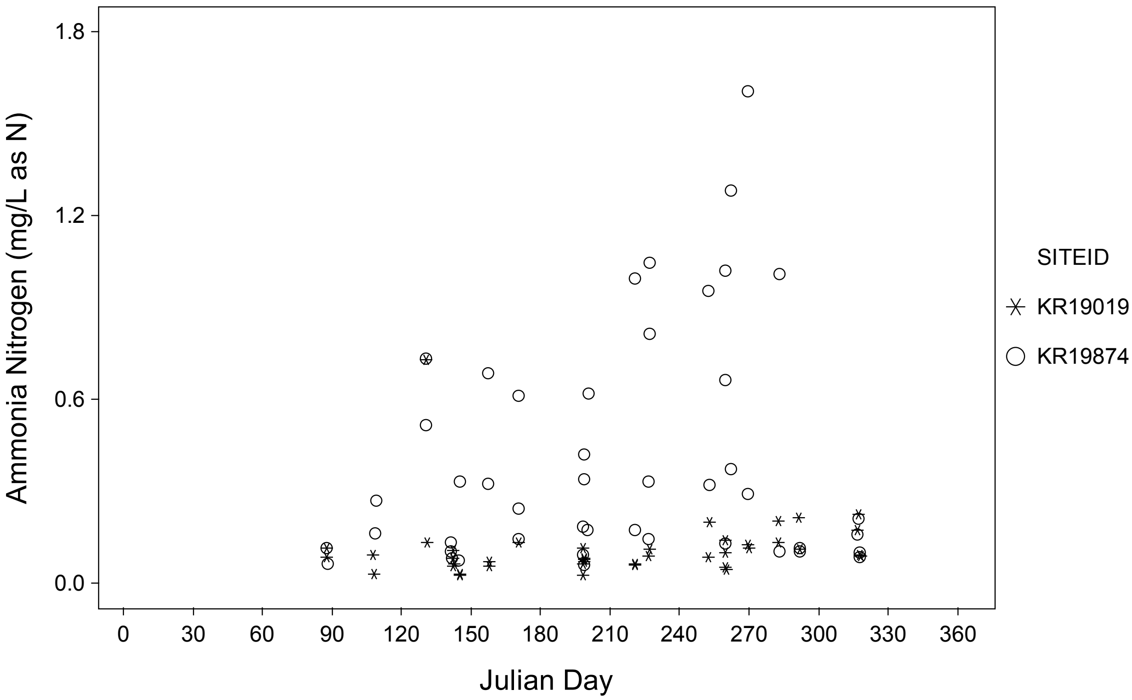


Figure E3.3-17. Oxidation-reduction values measured in Copco (KR19874) and Iron Gate (KR19019) reservoirs at depths > 10 m in 2002 and 2003.



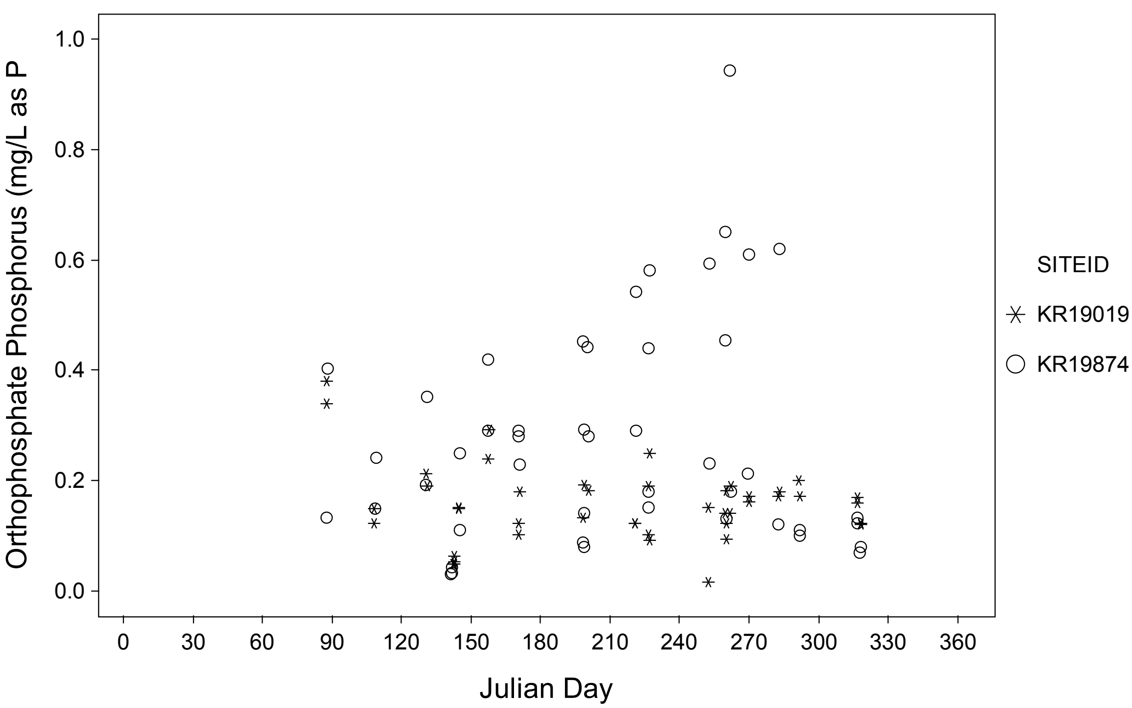


Figure E3.3-18. Ammonia nitrogen and orthophosphate phosphorus measured at depths > 10 m in Copco (KR19874) and Iron Gate (KR19019) reservoirs in 2000 through 2003.

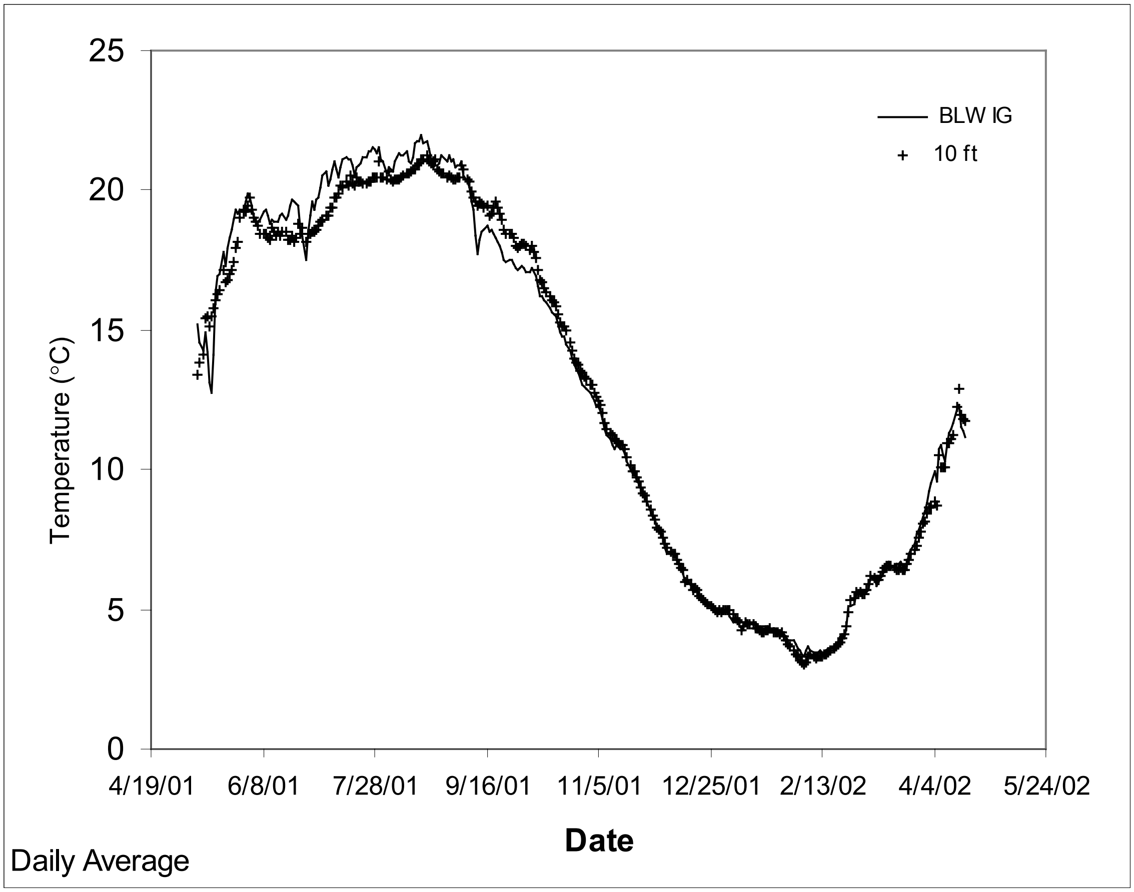


Figure E3.3-19. Daily average water temperature data from below Iron Gate dam and Iron Gate reservoir, showing the correspondence between the temperature in the reservoir at a 10-foot depth and the temperature in the Klamath River below Iron Gate dam.

The location of the power intakes in Copco and Iron Gate reservoirs suggests the possibility that water flowing through the hydropower project from J.C. Boyle reservoir may short-circuit and flow directly into the lower Klamath River with little mixing in Copco or Iron Gate reservoirs. Water flowing in the Klamath River from J.C. Boyle reservoir at a temperature near 15° to 18°C, even though cooler than when it left Keno reservoir, would not penetrate the thermocline in Copco reservoir. Instead, it would flow in the epilimnion to be discharged to the epilimnion of Iron Gate reservoir, from where it could discharge to the Klamath River. A result of this potential short-circuit is that higher nutrient concentrations in the hypolimnion of Copco reservoir during summer are sequestered in the hypolimnion. Figure 3.3-20 shows that increasing concentration of orthophosphate phosphorus and ammonia in the hypolimnion of Copco reservoir does not correspond to increasing concentration in the discharge from Copco reservoir, the hypolimnion of Iron Gate reservoir, or the discharge from Iron Gate reservoir.

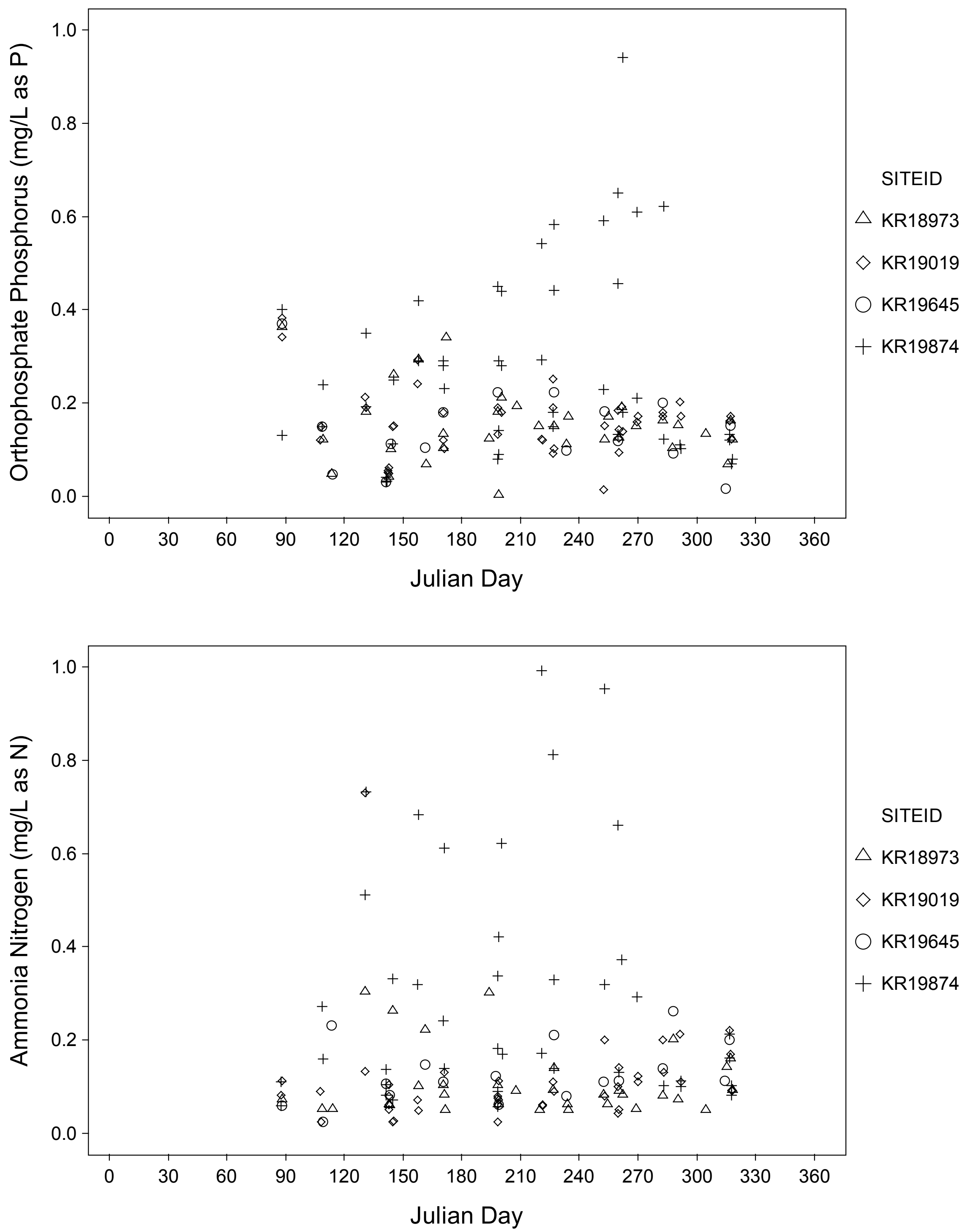


Figure E3.3-20. Orthophosphate phosphorus and ammonia nitrogen measured in the outflows from Copco (KR19645) and Iron Gate (KR18973) reservoirs, and at depths > 10 m in Copco (KR19874) and Iron Gate (KR19019) reservoirs in 2000 through 2003.

Chlorophyll *a* was analyzed on a 10-m-depth-integrated sample taken at the surface near the log boom in each reservoir. Occasional additional samples were taken at greater depths, and some surface grab samples were taken during obvious algal blooms. It is difficult to collect chlorophyll data that adequately represent the condition of the reservoirs during an algal bloom. Integrated samples may underestimate the local abundance of algae, while grab samples taken from a concentrated region of the bloom may substantially overestimate algal abundance.

Copco and Iron Gate reservoirs are highly productive, with many samples greater than 15 µg/L, a value commonly used as an indicator of eutrophic conditions. There is a predictable seasonal sequence of algae groups in the reservoirs. There is typically a bloom of diatoms in March, followed by a period of relatively low chlorophyll abundance. Another peak in chlorophyll occurs in July and August when dense blooms of the nitrogen-fixing cyanophyte (blue-green alga) *Aphanizomenon flos-aquae* occur. Later in the fall another, smaller bloom of diatoms occurs (Figure E3.3-21).

Aphanizomenon can regulate their buoyancy to concentrate into a shallow zone at the surface of the water and may drift with the wind to form highly a concentrated accumulation in a restricted area. Chlorophyll measured in the center of one of these accumulations exceeded 2,000 µg/L chlorophyll *a*, but the 10-m integrated sample at that spot was less than 40 µg/L.

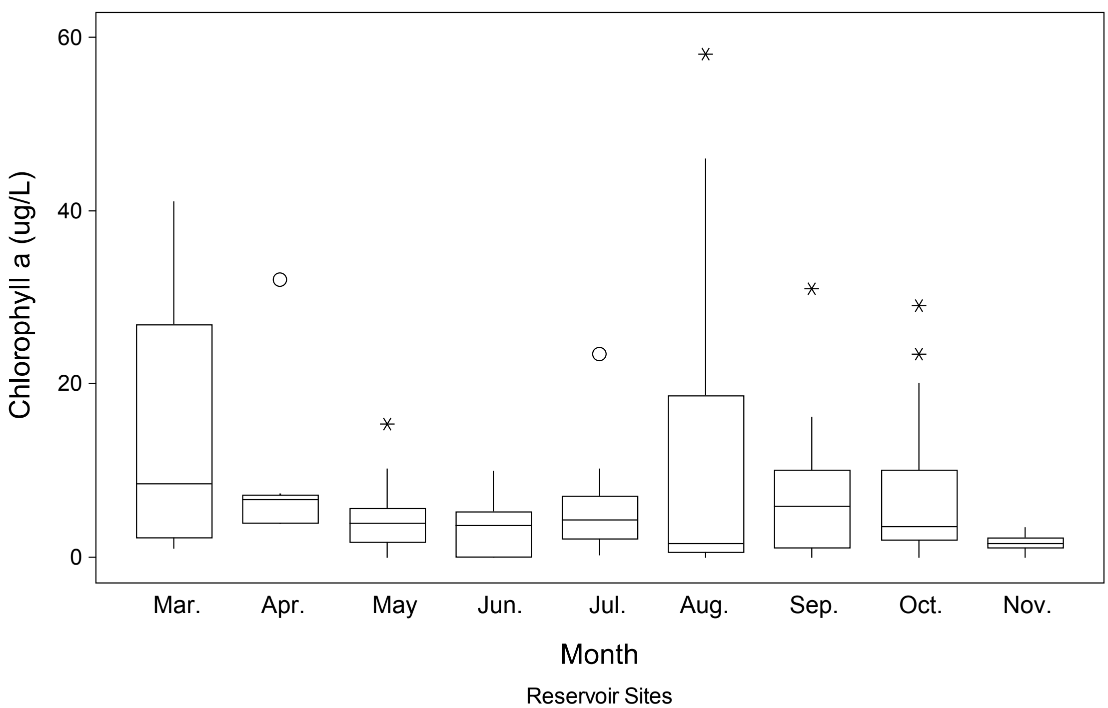


Figure E3.3-21. Box plot showing the distribution by month of chlorophyll *a* values measured in the reservoirs (Copco and Iron Gate, bottom) of the Project area during 2000-2003.

E3.3.5 Klamath River below Iron Gate Dam

Water quality in the Klamath River immediately below Iron Gate dam is similar to water quality in the epilimnion of Iron Gate reservoir and in the Klamath River above Iron Gate reservoir. As water progresses downstream from Iron Gate dam, water quality conditions change fairly rapidly. Previous water quality data (see section E3.2) indicate that nutrient concentration has increased just a few hundred meters downstream of Iron Gate dam. The changes are in excess of what would be expected as the result of in-river processes and suggest that there is a source of nutrients entering the Klamath River below Iron Gate dam.

Data collected in 2000 through 2003 below Iron Gate dam (KR18973) and above the Shasta River (KR17600) were compared to data collected in Iron Gate reservoir (KR19019) and at the site just upstream from Iron Gate reservoir just below the Copco No. 2 powerhouse tailrace (KR19645). The nonparametric Kruskal-Wallis analysis of variance followed by pairwise comparisons were used to detect differences among the sites for NO_3, NH_3, PO_4, PT, and TKN (Table E3.3-7). No significant differences were found between the sites for NH3, PO_4, or PT. The hypolimnion of Iron Gate reservoir had significantly higher concentration of NO_3 than the other sites, which did not differ from each other. The epilimnion of Iron Gate reservoir and the site below Iron Gate dam (KR19873) had lower concentration of TKN than the hypolimnion of Iron Gate reservoir (KR19019).

Table E3.3-7. Results of Kruskal-Wallis nonparametric analysis of variance for selected constituents at sites above and below Iron Gate dam ($P < 0.05$ indicates a significant difference).

Constituent	P value
NH_3	0.28
PO_4	0.73
PT	0.92
NO_3	0.00
TKN	0.00

Seasonal changes in water quality constituents below Iron Gate dam are not large (Table E3.3-8). Dissolved oxygen decreases through the summer, although results between sample years are quite variable. Ammonia remains fairly constant throughout the year, with occasional high values. NO_3 tends to increase slightly in the fall. PO_4 and PT are more variable in March through June than in other months. This corresponds to the period of year when concentrations of phosphorus are greatest in Klamath Straits Drain. TKN is higher in June and August when algal blooms occur in the reservoir.

The temperature of water leaving Iron Gate reservoir is less variable than the water temperature in the river above Copco reservoir. In the fall, before the breakdown of stratification, the water temperature leaving Iron Gate reservoir is warmer than the temperature in the Klamath River above Copco reservoir (Figure E3.3-21). This phenomenon is discussed in more detail in the Water Resources FTR, Section 4.0.

Table E3.3-8. Water quality constituents at sites sampled downstream from Iron Gate dam.

	Iron Gate Dam Discharge (KR19873), Median of All Years (mg/L)					Above Shasta River (KR17600), 2002 Data (mg/L)				
Month	**PT**	**DOCON**	**NH_3**	**NO_3**	**TKN**	**PT**	**DOCON**	**NH_3**	**NO_3**	**TKN**
March	0.38	12.4	0.07	0.23	0.70					
April	0.16	10.8	0.05	0.34	0.76					
May	0.22	10.2	0.16	0.12	0.40	0.16	11.2	0.06	0.02	0.70
June	0.21	9.11	0.10	0.11	0.80	0.24	10.2	0.04	0.02	1.00
July	0.17	8.06	0.10	0.28	0.80	0.15	10.7	0.06	0.07	0.40
August	0.15	7.98	0.06	0.24	1.3	0.12	10.4	0.13	0.22	0.90
September	0.18	7.51	0.08	0.57	0.90	0.17	11.1	0.19	0.23	0.60
October	0.16	6.59	0.08	0.49	0.70	0.15	8.16	0.09	0.21	0.50
November	0.12	8.64	0.14	0.42	0.70	0.20	15.0	0.10	0.33	0.70

DOCON = Dissolved oxygen concentration.

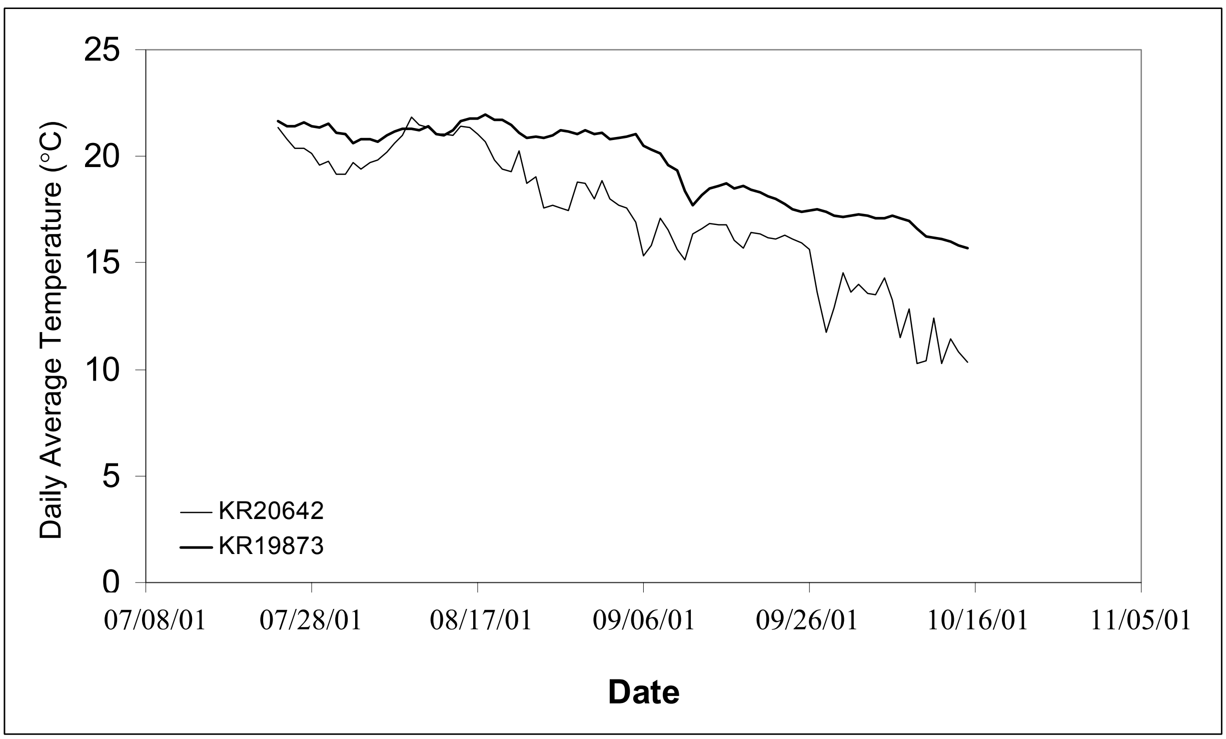


Figure E3.3-22. Hourly water temperature measured in the Klamath River upstream of Shovel Creek (KR20645) and just downstream of Iron Gate dam (KR18973).

E3.3.6 Macroinvertebrates

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

PacifiCorp used the California Stream Bioassessment Procedure (CSBP) and the California Lentic Bioassessment Procedure (CLBP) protocols adapted from the EPA's Rapid Bioassessment Protocols (CDFG, 1999a and 1999b). During the fall 2002 study, macroinvertebrate samples were collected in 21 lotic riverine reaches along the Klamath River from Link River dam (RM 254.3) to the mouth of the Shasta River (RM 176.7). Six additional stream reaches were sampled in Fall Creek. Keno, J.C. Boyle, Copco, and Iron Gate reservoirs were also sampled within this study reach. The fall 2002 lotic and lentic sites and sampling transects are summarized in Table E3.3-9.

During the spring 2003 study, the collection of macroinvertebrate samples occurred in 17 of the same lotic riverine reaches that were sampled in fall 2002. These included the lotic areas of (1) Keno dam to J.C. Boyle reservoir (Keno reach), (2) J.C. Boyle dam to J.C. Boyle powerhouse (J.C. Boyle bypass reach), (3) J.C. Boyle powerhouse to Copco No. 1 reservoir (J.C. Boyle peaking reach), and (4) Iron Gate dam to the confluence with the Shasta River. The Link River, Copco No. 2 bypass, Fall Creek, and reservoir sites were not sampled again in spring 2003. In discussions with the Water Quality Work Group, it was determined that the spring 2003 sampling could focus on key river reaches of most concern in the Project area, and that the lesser number of reaches and samples was sufficient for comparison with fall 2002 results to assess potential seasonal differences in macroinvertebrate community composition. The spring 2003 lotic sites and sampling transects are also summarized in Table E3.3-9.

Fall 2002 sampling occurred during September 6-14, 2002. Spring 2003 sampling occurred during May 19-23, 2003.

Table E3.3-9. Fall 2002 and spring 2003 lotic and lentic macroinvertebrate sampling transects by reach or area.

Area	Fall 2002	Spring 2003	Reaches[1]	Transects[2]	Samples[3]	State	
						OR	CA
Link River	√					√	
East Side/West Side Bypass Reach	√		1	3	3	√	
East Side/West Side Full Flow Reach	√		1	3	3	√	
Lake Ewauna/Keno Reservoir	√			5	2	√	
Keno Dam to J.C. Boyle Reservoir	√	√	2	6	6	√	
J.C. Boyle Reservoir	√			5	2	√	
J.C. Boyle Bypass Reach	√	√	3	9	9[4]	√	
J.C. Boyle Peaking Reach	√	√	6	18	18	√	√
Copco No. 1 Reservoir	√			5	2		√
Copco No. 2 Reservoir[5]	√			0	0		√
Copco No. 2 Bypass Reach	√		2	6	6		√
Copco No. 2 Full Flow Reach[6]	√		0	0	0		√
Fall Creek above Diversion	√		1	3	3		√
Fall Creek Bypass Reach	√		3	9	9		√
Fall Creek Full-Flow Reach	√		2	6	6		√
Iron Gate Reservoir	√			5	2		√
Klamath River between Iron Gate Dam and the Shasta River	√	√	6	18	18		√
Total			**27**	**101**	**89**		

[1] Reaches are defined as a stretch of stream that contains at least five riffles within the same stream order and relative gradient. Reach estimates for each area were derived from review of topographic maps and aerial photographs and initial field reconnaissance.

[2] For lotic areas, a sampling transect was placed in each of three randomly chosen riffles in each reach (in the upper third of the riffle). For lentic areas, five sampling transects were randomly chosen from assigned marks around the shoreline perimeter.

[3] For lotic areas, one sample was obtained at each sampling transect. The sample was a composite of kicknet collections from three areas along each transect. For lentic areas, slacknet collections from the five sampling transects were composited to produce one sample of littoral macroinvertebrates, and Ekman dredge collections from the five sampling transects were composited to produce one sample of benthic macroinvertebrates.

[4] Four additional composite samples were obtained in the varial zone at four of the transects in the J.C. Boyle peaking reach.

[5] Copco No. 2 reservoir is a small, steep-sided reregulating reservoir that was not sampled.

[6] The Copco No. 2 full-flow reach was not sampled since it is very short and inundated by the upper end of Iron Gate reservoir.

The CSBP and CLBP data analysis procedures are based on a multimetric approach to bioassessment data analysis. The taxonomic list and numbers of organisms reported for each sample was used to generate a table of sample values and means for several biological metrics in four categories: richness measures, composition measures, tolerance/intolerance measures, and functional feeding groups. Standard metrics used to analyze macroinvertebrate count data are listed in Table E3.3-10, along with an indication of the direction of change of each metric that typically infer better environmental conditions. In addition, sampling locations were grouped by macroinvertebrate metric results using cluster analysis and compared statistically among reaches to test for significant similarities or differences among sites.

Macroinvertebrate sampling results and data analysis are summarized below, and described in detail in the Water Resources FTR, Sections 8.0 and 12.0.

Table E3.3-10. Standard list of benthic macroinvertebrate metrics used in this analysis.

Metrics	Metrics
Total abundance, H	Total taxa richness, H
EPT taxa richness, H	EPT index, H
Sensitive EPT index, H	Shannon diversity (log e), H
Total ephemeroptera taxa, H	Total plecoptera taxa, H
Total trichoptera taxa, H	Tolerant taxa richness, L
Long-lived taxa %, H	Long-lived taxa richness, H
Tolerant taxa %, L	Intolerant taxa %, H
Hydropsychidae %, L	Baetidae %, L
Dominant taxa %, L	Collectors %, L
Filterers %, L	Scrapers (grazers) %, variable
Predators %, variable	Shredders %, H
Collector-filterer abundance, L	Collector-gatherer abundance, L
Predator taxa richness, H	Scraper abundance, variable
Scraper taxa richness, variable	Hilsenhoff Biotic Index (HBI score), L

Note: H or L = Better conditions that are represented by either Higher (H) or Lower (L) score (varying among metrics); H or L indicates the direction of the better, less impaired conditions. Variable = uncertain relationship between metric score and environmental conditions (CSBP, 2002).

Macroinvertebrate Community Composition

A listing of macroinvertebrate taxa identified from samples is presented in the Water Resources FTR, Sections 8.0 and 12.0. Dominant species in riverine reaches in fall 2002 and spring 2003 were similar and included caddisflies (*Hydropsyche* sp., *Hydroptila* sp., and *Amiocentrus aspilus*), blackfly (*Simulium* sp.), midges (*Rheotanytarsus* sp. and *Cricotopus* sp.), beetle (*Zaitzevia* sp.), and mayflies (*Baetis tricaudatus and Acentrella* sp.).

Many individual species occurred throughout the entire study area. For example, the mayfly (*Baetis tircaudatus*) and caddisfly (*Leucotrichia* sp.) were found throughout the study area, with peak abundances in the J.C. Boyle bypass reach, J.C. Boyle peaking reach, and mainstem Klamath River below Iron Gate dam. Some species were dominant in discontinuous reaches, such as the blackfly (*Simulium* sp.) in the J.C. Boyle bypass and lowermost river sections. Some, like the large stonefly (*Pteronarcys californica*), were found throughout the study area, but were most abundant in the reaches downstream of Iron Gate dam.

Three caddisfly Species of Concern[12] in the region were not found as part of these samples. However some little-described mollusc species (discussed further below) were found, and the small polychaete worm (*Manayunkia speciosa*), a host species for an important salmonid disease (*Ceratomyxa shasta*), was found in low abundance in the J.C. Boyle peaking reach in fall 2002 drift samples only, and in some of the spring 2003 kicknet samples.

Spatial Differences in the Macroinvertebrate Community

The macroinvertebrate communities of the riverine reaches revealed some differences among sites, most of which are attributable to expected differences associated with geographic elevation and gradient changes along the river (Figures E3.3-23 to E3.3-28). Existing conditions in the Project area include several distinct elevation and gradient changes along the nearly 79 miles of river from Link River (RM 254.3) to the confluence with the Shasta River (RM 176), punctuated by the presence of Keno, J.C. Boyle, Copco, and Iron Gate reservoirs. Metrics that generally showed longitudinal changes included taxa and EPT[13] taxa richness, the percent dominant taxa, and the EPT index (Figures E3.3-23 to E3.3-28).

Longitudinal changes in key invertebrate metrics show some trends moving downstream along the mainstem Klamath River. There appears to be a gradual increase in total taxa richness and total EPT[11] taxa richness moving downstream (Figures E3.3-24 and E3.3-26, respectively). All riverine reaches are dominated by collector and filter feeding groups, although some localized differences are found in the upper J.C. Boyle bypass reaches (Figure E3.3-27). The total macroinvertebrate density (Figure E3.3-23), Shannon diversity index (Figure E3.3-25), and percent dominant taxa (Figure E3.3-28) do not show consistent trends.

[12] The U.S. Fish and Wildlife Service has designated the following macroinvertebrate Species of Concern that could occur in the Project area: *Apatania (=Radema) tavala* (Cascades apatanian caddisfly), *Homoplectra schuhi* (Schuh's homoplectran caddisfly), and *Rhyacophila mosana* (Bilobed rhyacophilan caddisfly).

[13] EPT = ephemeroptera (mayflies), plecoptera (stoneflies), and trichoptera (caddisflies).

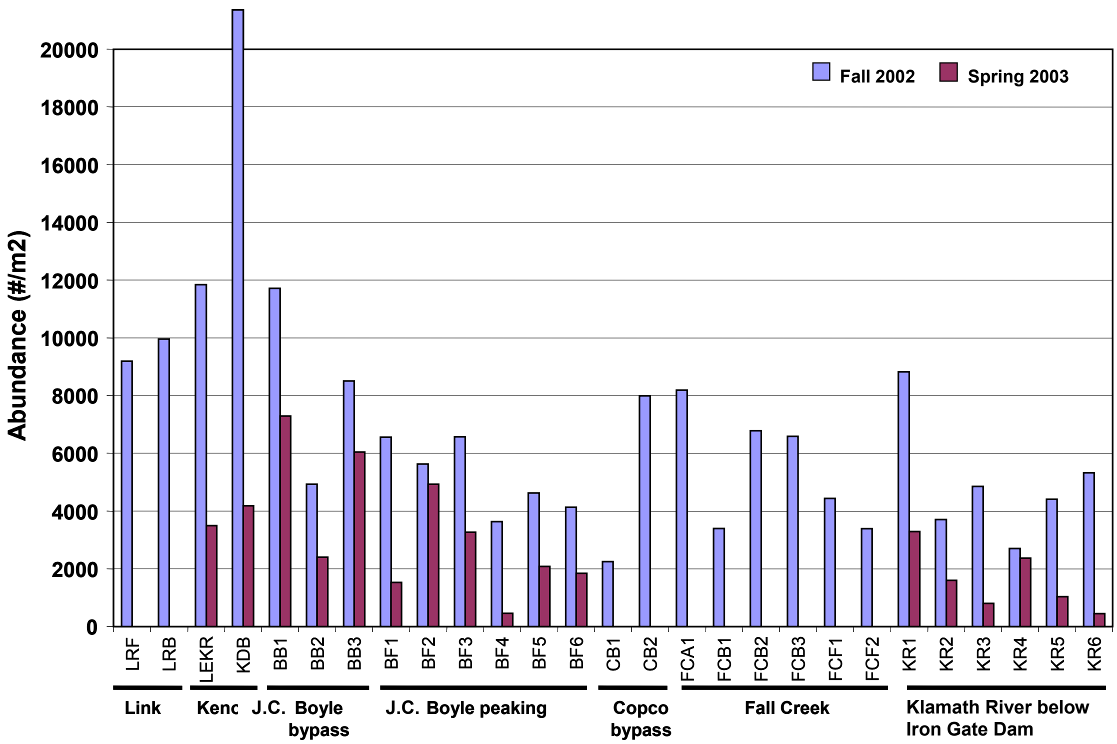


Figure E3.3-23. Total macroinvertebrate density (numbers/m2) by sampling location for fall 2002 and spring 2003 studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.

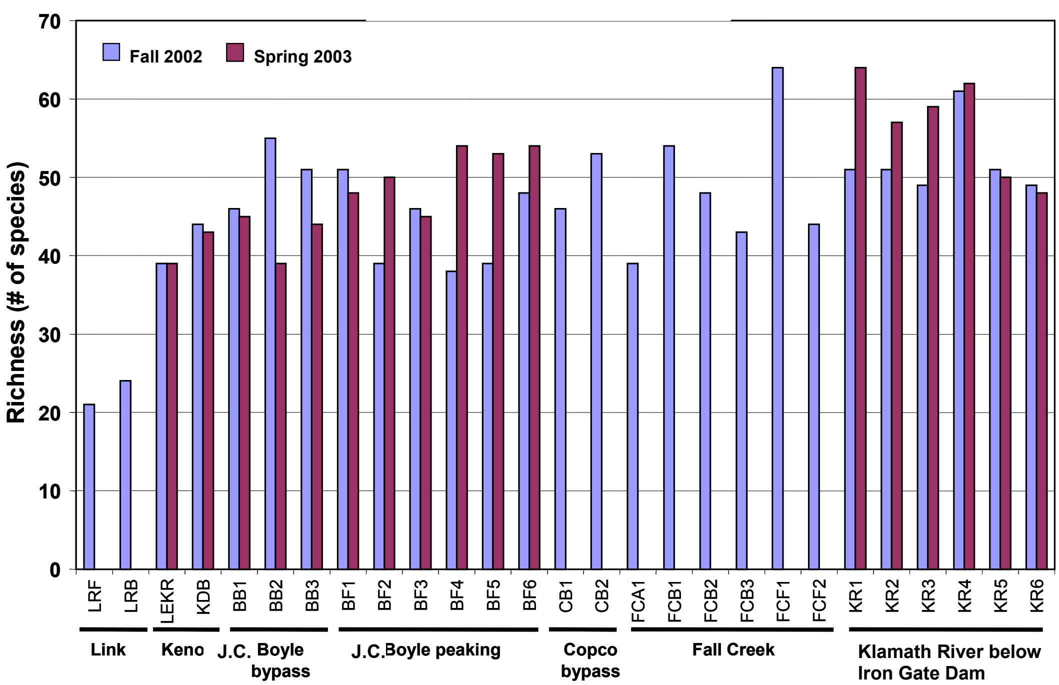


Figure E3.3-24. Total richness (number of species) by sampling location for fall 2002 and spring 2003 studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.

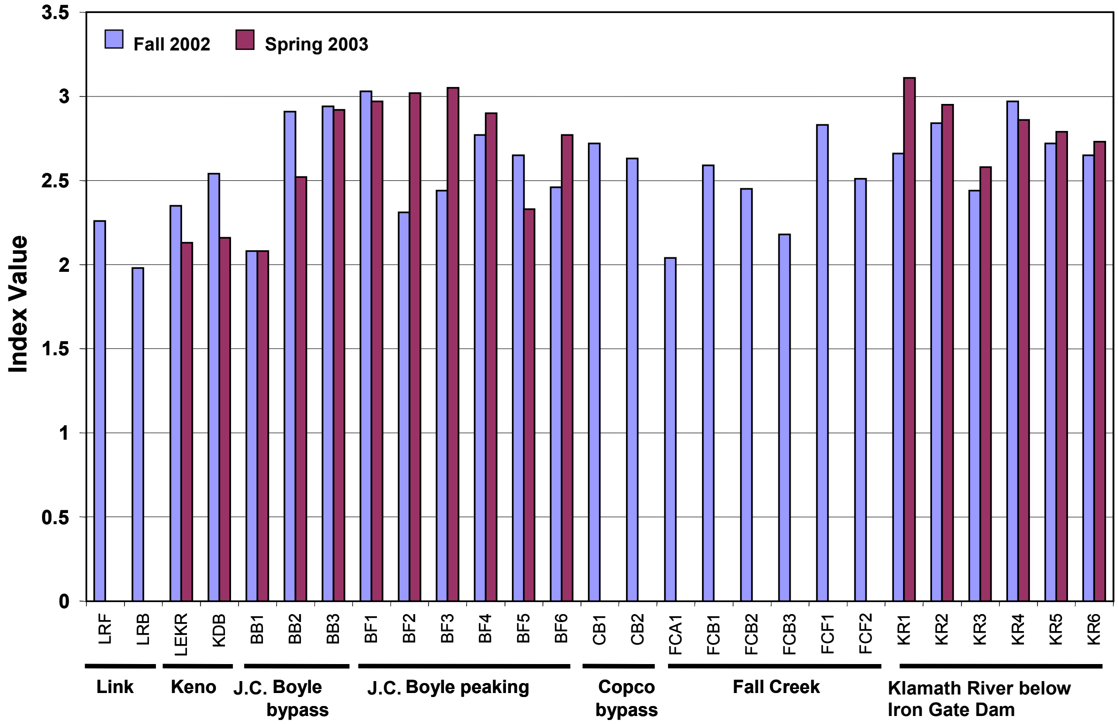


Figure E3.3-25. Shannon diversity index values by sampling location for fall 2002 and spring 2003 studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.

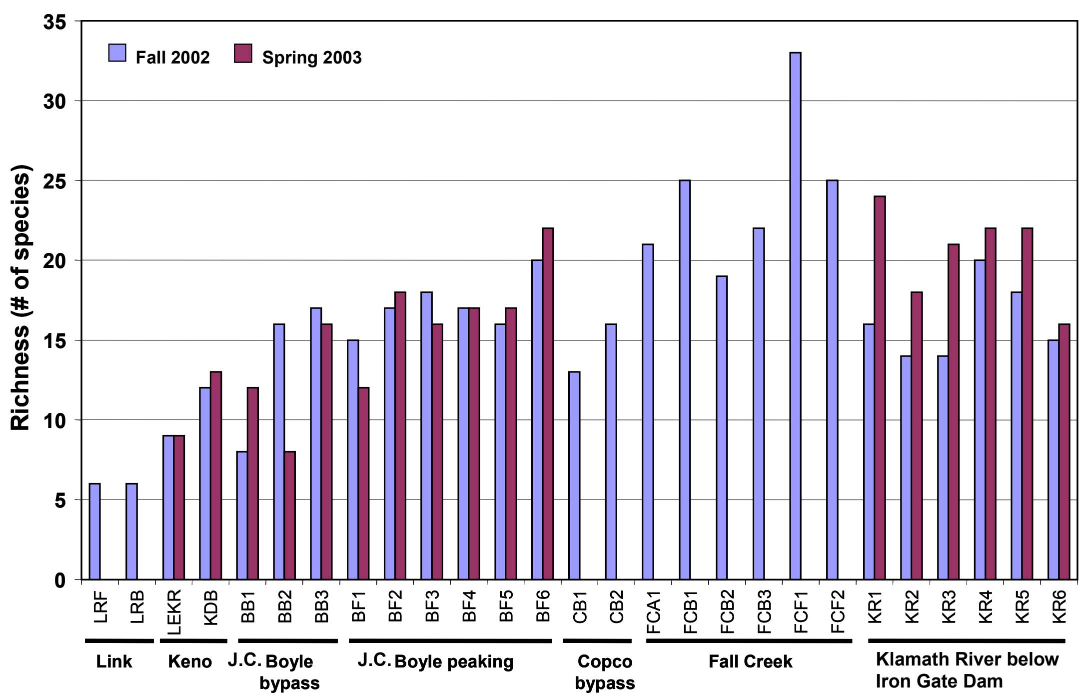
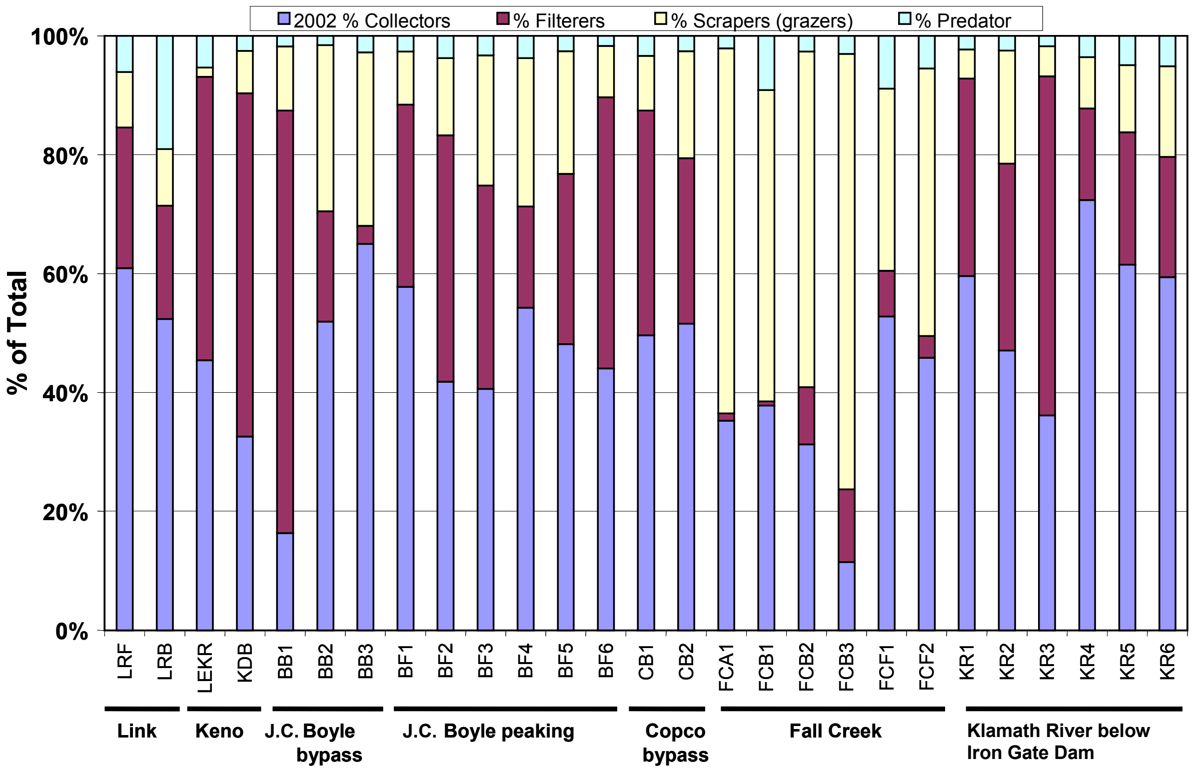


Figure E3.3-26. Total EPT richness (number of EPT species) by sampling location for fall 2002 and spring 2003 studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.



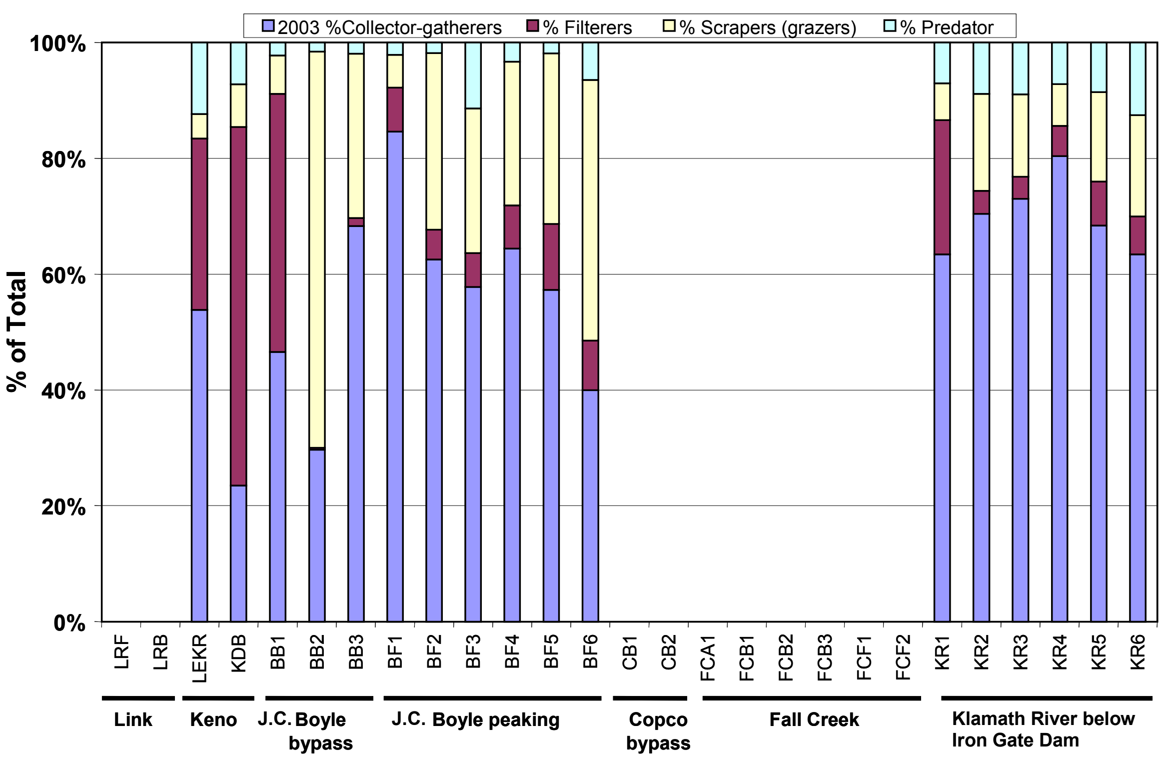


Figure E3.3-27. Macroinvertebrate functional groups by sampling location for fall 2002 (top plot) and spring 2003 (bottom plot) studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.

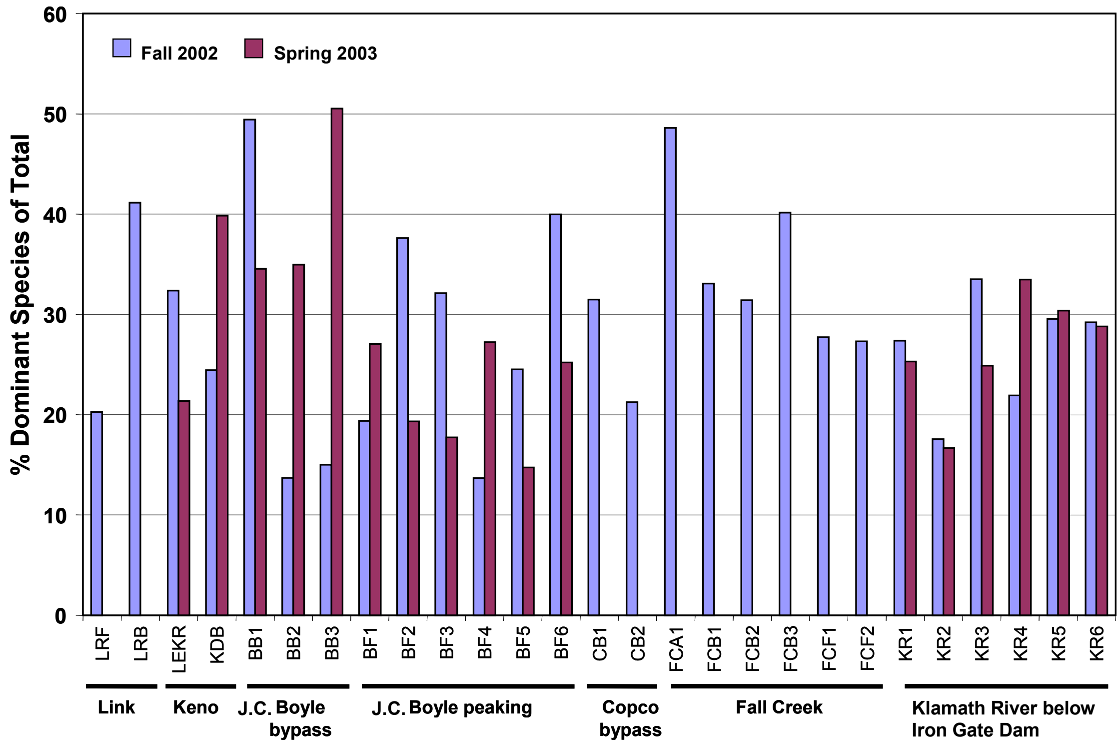


Figure E3.3-28. Macroinvertebrate dominant taxa (% of total taxa) by sampling location for fall 2002 (top plot) and spring 2003 (bottom plot) studies. See Sections 8.0 and 12.0 of the Water Resources FTR for descriptions of sample sites and Figure 8.4-1 for a map of specific sampling locations.

There is no longitudinally distinct evidence of impairment to macroinvertebrate communities that appears definitely related to Project operations. The most distinct site, where conditions may reflect Project operations, was BB1, the uppermost J.C. Boyle bypass section site. At that location, evidence for slightly degraded conditions included increased dominant taxa percentage, altered feeding guilds, decreased EPT index and taxa, and lowered Shannon diversity index (Figures E3.3-23 to E3.3-28). However, these degraded conditions appeared limited to that one site and did not persist in moving downstream through the rest of the reach.

The fall 2002 cluster analyses indicated three generally distinctive groupings of reaches with similar macroinvertebrate communities: (1) Fall Creek communities, (2) Link River and Keno reach communities; and (3) communities in all other reaches. Fall Creek and Link River/Keno reach groupings were distinct from other stations, particularly with respect to taxa richness, diversity and tolerance indices, and percentages in various functional feeding groups.
Table E3.3-11 presents results of statistical comparisons among reaches and, of those, identifies which reach ranks as “less impaired” (better than average conditions). From this analysis, it appears that from the Upper Klamath River through the J.C. Boyle bypass or from the J.C. Boyle peaking reach to the Klamath River’s confluence with the Shasta River, there are few statistically significant differences (Table E3.3-11).

Pairs of reaches were tested (by paired, t-test comparisons of metrics) for similarities, based on their close physical proximity. Overall, few significant differences were observed among these pairs of reaches. However, the tests indicated that the J.C. Boyle bypass and peaking reaches comparisons showed the greatest number of significant differences among metrics. The significant differences were split—i.e., 11 of the comparisons indicated evidence of better conditions in the peaking reach, three of the comparisons indicated better conditions in the bypass reach, and two were equivocal. Taken as a whole, over both seasons of sampling, the analysis of metrics does not indicate consistent, significant differences between the J.C. Boyle bypass and peaking reaches in macroinvertebrate community structure.

Table E3.3-11. Significant differences in macroinvertebrate metrics between adjacent mainstem reaches for fall 2002 sampling data.

J.C. Boyle: Peaking to Bypass	Fall Creek: Full-Flow to Bypass Reaches	Upper Klamath River to J.C. Boyle Bypass	J.C. Boyle Peaking to Lower Klamath River
Ephemeroptera taxa (BF)	Plecoptera taxa (FCF)	Abundance (UKR)	% Hydropsychidae (LKR)
% Hydropsychidae (BF)	% Baetidae (FCB)	% Hydropsychidae (BB)	% Baetidae (LKR)
EPT Index (BF)		EPT taxa richness (BB)	EPT Index (BF)
EPT taxa richness (BF)			
Intolerant taxa richness (BB)			
HBI (BF)			

Note: Abbreviations for stations with less impaired condition are shown. All relationships are significantly different, $P < 0.05$, ANOVA (analysis of variants).

The spring 2003 cluster analyses indicated three generally distinctive groupings of reaches with similar macroinvertebrate communities: (1) the Keno reach and the upper J.C. Boyle bypass reach communities; (2) the lower J.C. Boyle bypass and peaking reach communities; (3) the sites below Iron Gate dam. The greatest number of statistically significant differences in metric results by reach were found for the J.C. Boyle peaking reach compared to the J.C. Boyle bypass reach, immediately upstream (Table E3.3-12). Most major taxa metrics showed improved conditions in the peaking reach (EPT, sensitive EPT, diversity), but certain groups of taxa (long-lived and tolerant groups) showed enhanced conditions in the bypass reach. Only a few metrics showed statistically significant differences for the Keno reach/J.C. Boyle bypass comparison or the J.C. Boyle peaking reach/Lower Klamath sites comparison.

Table E3.3-12. Significant differences in macroinvertebrate metrics between adjacent mainstem reach for spring 2003 sampling data.

J.C. Boyle Peaking Reach to Bypass	Keno Reach to J.C. Boyle Bypass	J.C. Boyle Peaking Reach to Klamath below Iron Gate Dam
Taxa richness (P)	Tolerant taxa % (BB)	Intolerant taxa % (P)
EPT taxa richness (P)	Shannon diversity (K)	Baetidae % (P)
Sensitive EPT index (P)	Collector-filterer % (BB)	Predator % (Unk)
Tolerant taxa % (BB)	Scraper abundance (Unk)	Predator taxa (Unk)
Intolerant taxa % (P)	Predator % (Unk)	Sensitive EPT index (P)
Long lived taxa % (BB)		
Dominant taxa % (P)		
Shannon diversity (P)		
Scraper taxa (Unk)		
Scraper abundance (Unk)		

Note: Abbreviations for stations with less impaired condition are shown. All relationships are significantly different, $P < 0.05$, ANOVA.

Differences in the Macroinvertebrate Community between Fall 2002 and Spring 2003 Sampling

The metrics show general similarities in longitudinal trends between fall 2002 and spring 2003 sampling, although the absolute values of the metrics were variable between the two sampling seasons. For instance, although overall density estimates were lower in the spring, taxa richness differed little seasonally (see Figures E3.3-23 and E3.3-24). However, several metrics showed reach-specific differences or overall study area differences between the two sampling seasons (see Figures E3.3-26, E3.3-27, and E3.3-28). For example, the results indicate an apparent change between the two sampling seasons in the distribution of feeding guilds, possibly indicating changes in food type and availability (see Figure E3.3-28).

The generally better water quality conditions during spring 2003 sampling is reflected in the seasonal change to greater overall EPT taxa richness (see Figure E3.3-25). Other indicators of improved water quality conditions in spring (compared to fall) was the lower percentage of filterers in the J.C. Boyle peaking reach and in the river below Iron Gate (see Figure E3.3-27), and the reduced percentage of dominant species in the J.C. Boyle peaking reach (see Figure E3.3-28).

The results of fall/spring statistical comparisons of metrics by reach are summarized in Table E3.3-13. The J.C. Boyle peaking reach and area below Iron Gate dam registered the most change in macroinvertebrate community structure between the two seasons. Significant differences (Table E3.3-13) were driven by changed community structure between the seasons, mostly in terms of the relative decrease in filterers and increase in collector-gatherer taxa in the spring (Figure E3.3-28).

J.C. Boyle peaking and bypass comparisons were somewhat more distinctive in spring 2003 than fall 2002 results. Most spring 2003 results indicated improved conditions in the J.C. Boyle peaking reach compared with the bypass reach (Table E3.3-13). The uppermost bypass location, BB1, remains distinctive in exhibiting evidence for different and more degraded conditions than the other bypass locations.

The differences between seasons may indicate natural shifts in the macroinvertebrate community structure related to the variable life histories of the member species and to the changing food resources and water quality of the seasons. In general, the spring macroinvertebrate results, compared to the fall results indicate a shift toward better water quality. A greater percentage of EPT and sensitive EPT taxa were found in the spring, along with greater numbers of collector-gatherers and filterers in the peaking and most downstream reaches.

Seasonal differences as seen in the Keno and J.C. Boyle bypass reaches were not statistically different (Table E3.3-13). However, seasonal differences in most metrics are visible in the seasonal comparisons depicted in Figures E3.3-23 to E3.3-28 (including the Keno and J.C. Boyle bypass reaches).

Table E3.3-13. Paired t-test comparisons of fall 2002 and spring 2003 macroinvertebrate metrics by reach.

	Reach			
Metric	**Keno**	**J.C. Boyle Bypass**	**J.C. Boyle Peaking**	**Below Iron Gate Dam**
Total Taxa Richness	**S**	NS	**S**	**S**
EPT Taxa Richness	NS	NS	NS	**S**
EPT Index	NS	NS	**S**	**S**
Sensitive EPT Index	NS	NS	**S**	**S**
HBI	NS	NS	NS	NS
Shannon	NS	NS	NS	NS
Tolerant taxa, %	NS	NS	NS	NS
Intolerant taxa, %	NS	NS	**S**	**S**
Dominant taxa, %	NS	NS	NS	NS
Predators, %	NS	NS	NS	**S**
Baetidae, %	NS	NS	NS	**S**
Hydropsychidae, %	NS	**S**	**S**	**S**
Collector-filterer abundance	NS	NS	**S**	**S**
Collector-gatherer abundance	NS	NS	**S**	**S**

S = significantly different ($P < 0.05$).
NS = not statistically different.

<u>J.C. Boyle Reach Varial Zone Sampling</u>

The varial zone analysis showed a distinctly lower abundance and diversity of marcroinverte-brates in the varial zone of the J.C. Boyle peaking reach than in adjacent constantly wetted sampling sites. This is not surprising because the varial zones were dry for a portion of each day. As expected, abundance and taxa richness measures all favored the wetted, central channel samples. However, a few metrics favored varial zone results (percent Baetidae, Hydropsychidae, collectors, and tolerant taxa richness). The varial and mainstem zones were so close, spatially, that it is not surprising they share the same underlying faunal base. Thus, comparisons based on percent composition cannot be expected to be as distinct as those based on abundance.

<u>J.C. Boyle Reach Drift Sampling</u>

A separate set of macroinvertebrate samples was collected as riverine drift samples from nets set in the J.C. Boyle peaking reach. Three nets were sampled from sites at the margin and mid-channel at various times throughout a single day during which peaking operations occurred. Results are presented in the Water Resources FTR, Section 8.0.

When standardized by the volume of water passing the net over the sampling interval, some patterns emerged. As the peaking flows gained and lost more than 2 feet in stage height at the mid-channel net, the aquatic insects experienced an initial increase in drift, followed by a gradual (but highly variable) decline throughout the rest of the day. The peak in aquatic insect drift appeared near 10:00 a.m., while the peak in flows was at least 2 hours later. Terrestrial insect drift followed the same general pattern, but it was too low in density to allow for meaningful interpretation (Figure E3.3-29).

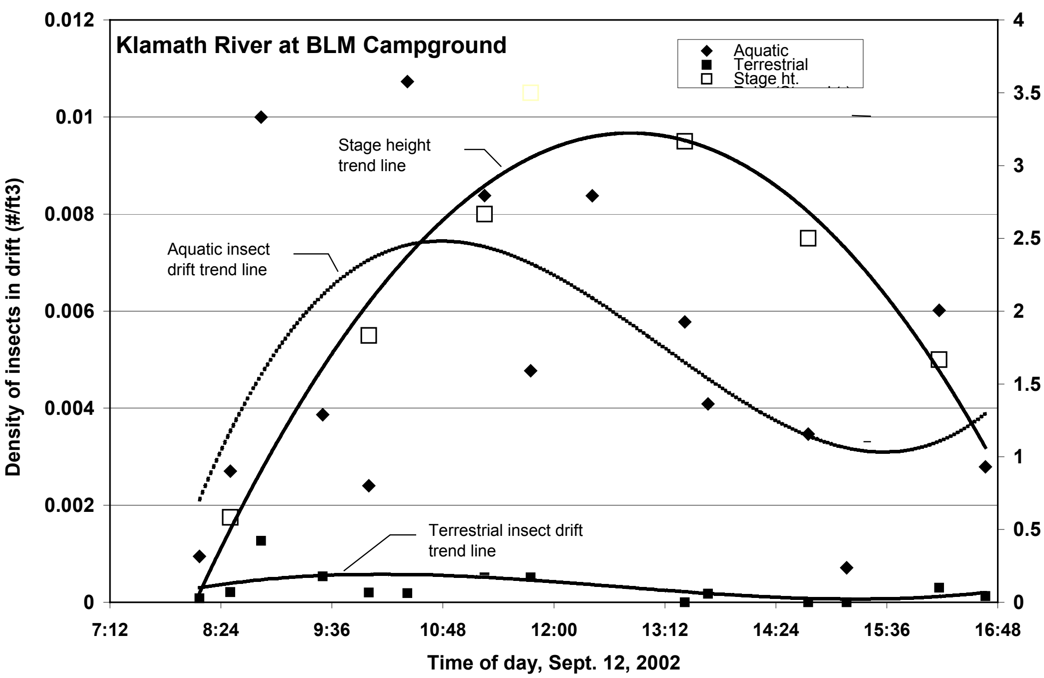


Figure E3.3-29. Macroinvertebrate drift in the J.C. Boyle peaking reach of the Klamath River during a peaking cycle on September 12, 2002. Combined results are from three channel sampling zones. Trend lines fitted to the data are based on third-order polynomials.

It is uncertain from this analysis whether aquatic insect drift was causally linked to the pulsed increase in flow or whether it followed a daily pattern related to invertebrate behavioral changes. Only one day was sampled, and flow-adjusted drift numbers were not statistically related to flow during this single day (P> 0.05, t-test). In general, drift varied by a factor of at least five over the course of the day (much more variable than flow) and was only roughly related to the pattern of changes in flow (see Figure E3.3-29). It is generally known that drift invertebrates are a selective subset of the benthic macroinvertebrate community and that drift is enhanced by increased velocity of flows (e.g., Hynes, 2001). The Klamath samples followed this general trend but did not yield a quantifiable positive relationship between drift and flow.

The drift sample results were generally supportive of the concept that drift is enhanced by increased flows. Because both drift and flows showed midday peaks. However, the relationship was statistically weak and the implications for river operations are unclear. For example, if drift is enhanced as a result of peaking flows, it is not clear that this is detrimental or significant to either the macroinvertebrate or fish communities. The small numbers of the polychaete host for *Ceratomyxa shasta* found in drift samples indicate the potential presence of the salmonid disease in the study reach (see the Fish Resources FTR for information on *C. Shasta*).

Macroinvertebrates in Project Reservoirs

The results for macroinvertebrate abundance and diversity from reservoirs are not strictly comparable to riverine data. Standard lentic CDFG protocols were followed and invertebrates were collected at all sites. Molluscs were enumerated separately, in detail. However, much less is known about the ecological meaning of differences in community structure as observed among groups of lake sediment invertebrates. Count and metric results are presented in the Water Resources FTR, Section 8.0.

Some limited patterns are evident in the reservoir results. A lack of replicate samples by sampling type per reservoir (as would be similar to the replication within river reaches) limited the ability to statistically separate reservoirs on the basis of metric values. The two samples taken at each reservoir were collected using two independent methods and are meant to be complementary rather than to provide duplicate samples. Nevertheless, when grouped by reservoir, limited patterns were observable. The invertebrate fauna of Lake Ewauna/Keno reservoir showed evidence of impairment compared to the communities of the other lakes. Results are summarized in Table E3.3-14.

Table E3.3-14. Distinct macroinvertebrate metrics indicating impaired conditions at Lake Ewauna ($P < 0.05$, ANOVA).

Metric	Statistically Distinct Reservoir from Lake Ewauna/Keno Reservoir	Community Condition of Lake Ewauna/Keno Reservoir Relative to Other Reservoirs
Total Invertebrate Density	All others	Greater abundance
Species Diversity (Shannon)	All others	Lower diversity
Dominant Taxa, %	Copco, Iron Gate	Greater %
Tolerant Taxa, %	All others	Lower %
Mollusc Density*	J.C. Boyle	Lower density

*Iron Gate is also statistically lower density than J.C. Boyle.

The invertebrate community of Lake Ewauna/Keno reservoir displayed a number of distinct characteristics indicative of more stressed conditions than the other reservoirs. Although possessing greater invertebrate abundance (but not of molluscs), diversity was low and the community was dominated by only a few species (Table E3.3-14). Other metrics were statistically similar among the reservoirs. Some taxa, such as plecoptera, were not expected and were not found in the lakes. In general, the fauna from all lakes was dominated by "tolerant" taxa—i.e., those taxa judged most tolerant of impaired conditions. The tolerant taxa group was dominated by Chironomid midges in all reservoirs.

The reservoirs were dominated by tolerant fauna (as compared to the streams) and were basically similar to each other in terms of community structure, with the exception of Lake Ewauna/Keno reservoir. The macroinvertebrate community of Lake Ewauna/Keno reservoir was dominated by a few tolerant species, with overall lowered species diversity but high abundance. It is not known what specific factors are responsible for generally degraded macroinvertebrate community conditions at this reservoir. However, detailed and long-term water chemistry sampling at the reservoirs provides some supportive evidence for water quality impairment at Lake Ewauna/ Keno reservoir compared with the other reservoirs. Lake Ewauna/Keno reservoir has highly enriched conditions, excessive algae growth, and summertime depletion of dissolved oxygen (see earlier discussion of Lake Ewauna/Keno reservoir).

Molluscs

The Klamath River basin is a highly diverse region for freshwater mollusc species. Aquatic mollusks may be found in lotic and lentic habitats, with springs containing the most diversity and endemism of species. Based on the literature review, 37 species of aquatic molluscs have been identified in or adjacent to the Project area (Frest and Johannes, 1998; Taylor, 1981). Species are found to transition through the available habitats, with obvious differences in species composition among the reaches. Highly diverse and endemic populations are associated with springs and are found adjacent to lotic habitat (spring runs), in the river in the form of seeps (riverine), or as large groundwater accretions within lentic habitats. Endemism occurs in the genera *Fluminicola, Juga, Lyogyrus, Pyrgulopsis, Vorticifex, Lanx,* and *Carinifex* (Frest and Johannes, 1998). Less disturbed tributary systems and their associated springs, such as Fall Creek and Jenny Creek in the mid-Klamath River basin, contain a high number (six) of endemic species from the genera *Juga* (Frest and Johannes, 2000).

Molluscs were sampled as part of the macroinvertebrate kicknet samples taken in fall 2002 and spring 2003, as described in the Water Resources FTR, Sections 8.0 and 12.0. Large bivalves were sampled in a separate study described in the Water Resources FTR, Section 11.0. The geographic scope of the focused bivalve study included the Keno reach, the J.C. Boyle peaking reach, and the Klamath River between Iron Gate dam and the Shasta River confluence.

Stations along the mainstem Klamath River were generally similar in species diversity and abundance of small mollusc species. Fall Creek had a more diverse and abundant small mollusc community than did the mainstem Klamath River sites. Samples from riverine reaches contained several species of freshwater bivalves, some of which were notably abundant. Tiny peaclams (*Pisidium insigne*) and ubiquitous peaclams (*P. casertanum*) were found abundantly at several stations within Fall Creek. Ubiquitous peaclams, grooved fingernailclams (*Sphaerium simile*), and montane peaclams (*P. ultramontanum*) were found at several stations within the J.C. Boyle peaking reach. This latter species was also found at J.C. Boyle peaking reach station KR2. Pond fingernailclams (*S. securis*) were found only at Keno reach station KEKR in the spring 2003 survey. Lake fingernailclams and triangular peaclams (*P. variabile*) were found in the Copco, J.C. Boyle, and Keno reservoirs, with the latter species also found in Iron Gate reservoir.

Focused field surveys for large bivalves were conducted September 2-6, 2003, within the three Project area reaches noted earlier. Eight sampling stations were established among the three Project area reaches, with two stations located in the Keno reach (at RM 228 and 233), one station in the J.C. Boyle peaking reach (at RM 205.2), and five stations in the reach between Iron Gate dam and the Shasta River (at RM 178.6, 179.3, 180.6, 185.6, and 189.8). Locating areas of suitable bivalve habitat within the J.C. Boyle peaking reach proved difficult because of the abundance of boulder substrate and scarcity of finer soils in this reach. Thus, a single sampling station was established in the peaking reach. Detailed descriptions of station locations and habitat characteristics are provided in the Water Resources FTR, Section 11.0.

Two unionid mussel species were observed in the three Project area reaches investigated: the Oregon floater (*Anodonta oregonensis*) and the western ridgemussel (*Gonidea angulata*). *Anodonta oregonensis* was found at both stations in the Keno reach and at three of five sampled stations in the reach between Iron Gate dam and the Shasta River, but it was most abundant at Keno reach station KR-1 (RM 233) and station FFR-1 (RM 189.8) in the reach between Iron Gate dam and the Shasta River. *Gonidea angulata* was found at one of two sampled stations in the Keno reach, at the single J.C. Boyle peaking reach station, and at four of five sampled stations in the reach between Iron Gate dam and the Shasta River. This species was most abundant at Keno reach station KR-2, but it was most expansively distributed at stations FFR-1 (RM 189.8) and FFR-3 (RM 180.6) in the reach between Iron Gate dam and the Shasta River.

The distribution of large bivalves within the study area is patchy and is strongly related to the patchy distribution of suitable habitat. Low-energy areas where sediments accumulate and where hydrology is consistent were most suitable for *Anodonta oregonensis*. While these types of habitats also supported *Gonidea angulata*, this latter species appeared to prefer faster waters and, consequently, coarser substrates such as medium and coarse sands.

Both species could be exceptionally dense where found. Commonly, *Gonidea* were found buried to depths of 6 inches, oftentimes atop one another. *Gonidea* were always buried at least 80 percent, with only the tops of shells evident. In contrast, *Anodonta* were sometimes found lying atop the bottom substrate. Others were buried slightly, but never to the extent that the *Gonidea* were buried.

Follow-up laboratory examination of samples of *Gonidea* (unmeasured, but approximately 70 to 105 millimeters [mm] in length) ranged from 10 to 50+ years in age. Similarly, *Anodonta oregonensis* material (also unmeasured, but up to approximately 90 mm in length) ranged from 8 to 20 years old. Hanson et al. (1988) reported that northern floaters in Narrow Lake, Canada, were approximately 50 mm at age 5, 55 mm at age 6, and 60 to 70 mm at ages 7 to 10. Cohort recruitment was not readily apparent at any sampled station, as small animals less than 50 mm in length were uncommon to rare.

Based on the September 2003 observations within accessible portions of the Project area, it is unlikely that the J.C. Boyle peaking reach supports broadly distributed populations of large unionid bivalves. This may be due to the high gradient nature of this reach. In contrast, selected microhabitats within the Keno reach and the Klamath River between Iron Gate dam and the

Shasta River appear to support locally extensive populations of both *Anodonta oregonensis* and *Gonidea angulata*. Of the two, the latter appears more broadly distributed, possibly reflecting the relative abundance of preferred habitat (faster water, coarser substrate) and relative scarcity of slower, nutrient enriched habitats (e.g., nearly eutrophic lakes).

E3.4 APPLICABLE REGULATIONS, STANDARDS, AND PLANS

E3.4.1 Federal Water Pollution Control Act (Clean Water Act), 33 USC §§ 1251-1387

Congress has delegated the primary responsibilities for implementing the Clean Water Act (CWA) to the United States Environmental Protection Agency (USEPA) and the states. In Oregon, the Oregon Department of Environmental Quality is the state agency that is primarily responsible for implementing the CWA. In California, the California State Water Resources Control Board (CSWRCB) and California's nine Regional Water Quality Control Boards (RWQCBs) work in a coordinated effort to implement the CWA in California.

E3.4.1.1 Water Quality Certification (Section 401)

Section 401 of the CWA requires that an applicant for a federal license or permit to conduct any activity that may result in a discharge to waters of the United States must provide the licensing or permitting agency with a certification from the state in which the discharge originates that the discharge will comply with the applicable provisions of CWA Sections 301, 302, 303, 306, and 307, including state water quality standards approved by USEPA pursuant to Section 303. Certification may include conditions to assure compliance with these provisions and other appropriate requirements of state law. ODEQ and CSWRCB are the state agencies authorized to issue Section 401 certifications to FERC-licensed hydroelectric projects in Oregon and California, respectively.

FERC's relicensing regulations require that PacifiCorp request certification under Section 401 for the Klamath Hydroelectric Project no later than 60 days after FERC issues the notice that the relicensing application has been accepted and is ready for environmental analysis. PacifiCorp will request certification from ODEQ and CSWRCB by that date.

E3.4.1.2 Water Quality Standards (Section 303)

CWA Section 303 requires that the states adopt, and submit for USEPA approval, water quality standards for surface waters of the United States. The states of Oregon and California have established and obtained EPA approval of water quality standards (referred to as "water quality objectives" in California) for waters in the Project area, including designated beneficial uses for the waters and water quality criteria to protect the designated uses.[14] Water quality standards for key parameters are summarized in Table E3.4-1.

[14] In December 2003, the Oregon Environmental Quality Commission revised and renumbered Oregon's water quality standards. *See* OAR chapter 340, division 041. USEPA approval of the revised and renumbered standards under CWA Section 303 is pending. In addition, in October 2003, USEPA proposed federal water quality standards for Oregon under Section 303. *See* 68 Fed. Reg. 58,758 (Oct. 10, 2003). USEPA is under a federal district court order to approve Oregon's revised and renumbered standards or promulgate federal water quality standards for Oregon by March 2, 2004. *See id.* PacifiCorp assumes that USEPA will approve Oregon's revised and renumbered water quality standards, which were developed in consultation with USEPA. Accordingly, this assessment of applicable regulations, standards, and plans is based on the revised and renumbered Oregon water quality standards adopted in December 2003. The California water quality standards are based on the North Coast Regional Water Quality Control Board Basin Plan posted at http://www.swrcb.ca.gov/rwqcb1/programs/basin.html (accessed on January 7, 2004).

Oregon has designated in OAR 340-041-0180, table 180A, the following beneficial uses in Klamath River basin waters that are associated with the Klamath Hydroelectric Project:

- Domestic (public and private) water supply (with adequate pretreatment)
- Industrial water supply
- Irrigation
- Livestock watering
- Fish and aquatic life[15]
  - Cool water species (no salmonid use) in the Klamath River from Upper Klamath Lake to Keno Dam
  - Lahontan cutthroat or redband trout use, except in the Klamath River from Upper Klamath Lake to Keno Dam
- Wildlife and hunting
- Fishing
- Boating
- Water contact recreation
- Aesthetic quality
- Hydropower (Klamath River from Upper Klamath Lake to Keno dam)
- Commercial navigation and transportation (Klamath River from Upper Klamath Lake to Keno dam)

In California, the Water Quality Control Plan for the North Coast Region (NCRWQCB, 1994), adopted and amended by the North Coast Regional Water Quality Control Board and approved by the State Water Resources Control Board, lists the following existing beneficial uses for the Middle and Lower Klamath River Hydrologic Areas (HAs):[16]

- Municipal and domestic supply (excluding the Iron Gate and Copco reservoir hydrologic subareas [HSAs])
- Agricultural supply (excluding the Iron Gate and Copco reservoir HSAs)

[15] Fish uses are designated in Figure 180A, OAR 340-41-0180.

[16] The Middle Klamath River Hydrologic Area (HA) is divided into seven hydrologic subareas (HSAs), which cover the Iron Gate and Copco Reservoir reaches (Iron Gate and Copco HSAs), and the reach extending from the confluence with Willow Creek downstream to the confluence with the Salmon River. The Lower Klamath River HA begins downstream of the confluence with the Salmon River, and extends to the Pacific Ocean.

- Industrial service and process supply (excluding the Iron Gate and Copco Reservoir HSAs and the Lower Klamath River HA)
- Groundwater recharge (excluding the Iron Gate and Copco Reservoir HSAs)
- Freshwater replenishment
- Navigation (Lower Klamath River HA only)
- Hydropower generation (excluding Lower Klamath River HA)
- Water contact and noncontact water recreation
- Commercial and sport fishing
- Aquaculture
- Warm freshwater habitat
- Cold freshwater habitat
- Estuarine habitat (Lower Klamath River HA only)
- Wildlife habitat
- Rare, threatened, and endangered species (excluding the Lower Klamath River HA)
- Migration of aquatic organisms
- Spawning, reproduction, and/or early development of fish

Potential beneficial uses listed in the Basin Plan for the Middle Klamath River HA include:

- Municipal and domestic supply (Iron Gate and Copco Reservoir HSAs)
- Agricultural supply (Iron Gate and Copco Reservoir HSAs)
- Industrial service and process supply (Lower Klamath River HA and Iron Gate and Copco Reservoir HSAs)

Table E3.4-1. A summary of Oregon and California water quality criteria for key water quality constituents for the Klamath Basin in the vicinity of the Klamath Hydroelectric Project. Refer to OAR 340-041-0001 through -0061 and -0180 through -0185 (Oregon) and to the Water Quality Control Plan for the North Coast Region (California) for details on water quality criteria.

Constituent	**Oregon Criteria**	**California Criteria**	**Included in Final 2002 303(d) List**[1]						
			UKL	**EWA**	**KEO**	**BOY**	**KRA**	**KRB**	**KRC**
Dissolved oxygen	At DEQ discretion, for waters designated for cool-water aquatic life, 30-day (D) mean minimum (min) 6.5 mg/L, 7-D mean min 5.0 mg/L, and absolute min 4.0 mg/L. At DEQ discretion, for waters designated for cold-water aquatic life, 30-D mean min 8.0 mg/L, 7-D min mean 6.5 mg/L, and absolute min 6.0 mg/L. Not less than 11.0 mg/L in active spawning areas used by resident trout species unless the minimum spatial median intergravel dissolved oxygen is 8.0 mg/L or more, in which case the criterion is 9.0 mg/L.	Minimum of 7.0 mg/L above Iron Gate dam and 8.0 mg/L below Iron Gate dam 50% lower limit[2] of 10.0 mg/L above and below Iron Gate dam	Yes		Yes			Yes	Yes
Temperature	7-day average maximum (max) not to exceed 20ºC in waters designated for redband trout.[3] Designated cool water habitat may not be warmed more than 0.3ºC above ambient temperatures unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life. If the natural thermal potential of a water body is determined to exceed the applicable criterion, the natural thermal potential becomes the applicable criterion. A cumulative temperature increase of 0.3ºC above the applicable criterion is allowed in all waters.	Shall not be altered unless demonstrated that such alteration does not adversely affect beneficial uses. At no time shall temperature be increased by more than 5ºF above natural receiving water temperature.		Yes	Yes	Yes	Yes	Yes	Yes

Table E3.4-1. A summary of Oregon and California water quality criteria for key water quality constituents for the Klamath Basin in the vicinity of the Klamath Hydroelectric Project. Refer to OAR 340-041-0001 through -0061 and -0180 through -0185 (Oregon) and to the Water Quality Control Plan for the North Coast Region (California) for details on water quality criteria.

Constituent	Oregon Criteria	California Criteria	Included in Final 2002 303(d) List[1]						
			UKL	EWA	KEO	BOY	KRA	KRB	KRC
Nuisance phytoplankton growth (Oregon) and nutrients (California)	If chlorophyll *a* exceeds an action level of 0.015 mg/L[4], ODEQ may conduct studies to determine impacts, causes, and control strategies. Where natural conditions exceed the action level, the action level may be modified to an appropriate value.	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths sufficient to cause nuisance or adverse effects.	Yes	Yes	Yes			Yes	Yes
pH	Values shall not fall outside the range of 6.5-9.0.[5]	Values shall not fall outside the range of 7.0-8.5.	Yes	Yes	Yes				
Toxic substances (including ammonia)	Shall not exceed criteria listed in OAR 340-041-0033, Table 20.	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life.			Yes (ammonia)				
Turbidity (NTU)	Except for certain limited duration activities, no more than a 10% increase above natural background levels, as measured relative to a control point immediately upstream of the turbidity causing activity.	No more than 20% increase above natural background levels (except as otherwise allowed by permit or waiver)							
Total dissolved gas	Shall not exceed 110% saturation.[6] Shall not exceed 105% saturation in water < 2-ft in depth.								
Total dissolved solids or specific conductance	Unless otherwise authorized by ODEQ, specific conductance shall not exceed a guideline value of 400 micromhos (measured at 77°F) at the Oregon-California border (RM 208.5).	90% and 50% upper limits of 425 and 275 micromhos, respectively, above Iron Gate dam. 90% and 50% upper limits of 350 and 275 micromhos, respectively, below Iron Gate dam.							

Table E3.4-1. A summary of Oregon and California water quality criteria for key water quality constituents for the Klamath Basin in the vicinity of the Klamath Hydroelectric Project. Refer to OAR 340-041-0001 through -0061 and -0180 through -0185 (Oregon) and to the Water Quality Control Plan for the North Coast Region (California) for details on water quality criteria.

Constituent	Oregon Criteria	California Criteria	Included in Final 2002 303(d) List[1]						
			UKL	EWA	KEO	BOY	KRA	KRB	KRC
Taste and odor	The creation of tastes or odors deleterious to aquatic life, the potability of drinking water or the palatability of fish or shellfish may not be allowed.	Shall not contain taste or odor producing substances that impart undesirable taste of odors to fish flesh or adversely affect beneficial uses.							
Color	Objectionable discoloration may not be allowed.	Waters free of coloration that adversely affects beneficial use							
Floating material	Objectionable floating solids are not allowed.	Shall not contain floating solids, liquids, foams or scum that adversely affect beneficial uses.							
Naturally occurring conditions	Less stringent natural conditions that exceed a numeric criterion become the standard.								

[1]UKL: Upper Klamath Lake; EWA: Klamath Lake to Lake Ewauna; KEO: Link River to Keno dam; BOY: J.C. Boyle reservoir; KRA: Keno dam to the California border; KRB: Oregon border to Iron Gate dam; KRC: Iron Gate dam to Scott River. Oregon's current (2002) Section 303(d) list is based on Oregon's water quality standards as they existed before the December 2003 revision and renumbering of the standards.
[2]50% and 90% upper and lower limits represent the 50th and 90th percentile values, respectively, of monthly means for a calendar year.
[3]Exceedances of temperature criteria are not violations if they occur during the warmest 7-day period of the year that exceeds the 90th percentile of the 7-day average daily max air temperature calculated in a yearly series over the historic record.
[4]Calculated from a minimum of three depth-integrated samples collected over three consecutive months at a minimum of one representative site.
[5]Exceedance of this criterion is not a violation if it occurs in waters impounded by dams existing on January 1, 1996, provided all practicable measures have been taken to bring pH into compliance.
[6]Exceedances of total dissolved gas criteria are not violations if they occur when stream flow exceeds the 10-year, 7-day average flood.

E3.4.1.3 303d Listed Water Bodies and TMDL Processes (Section 303 d)

Pursuant to CWA Section 303(d), Oregon and California have listed portions of the Klamath River as not meeting applicable water quality standards. Specific constituents and locations included on the 303(d) lists are summarized in Table E3.4-1. Note that the most recent Oregon Section 303(d) list in 2002 was based on water quality standards that have since been revised and renumbered.

Also pursuant to Section 303(d), ODEQ and California are developing TMDLs and associated wasteload and load allocations for point and nonpoint sources, respectively, for the pollutants for which the Klamath River has been listed under that section. ODEQ has established a target date of 2004 for completing TMDLs for the Klamath River downstream of Upper Klamath Lake, although the TMDLs may require somewhat longer to complete. TMDLs for temperature, nutrients, and dissolved oxygen are scheduled for completion for the Klamath River in California by December 31, 2007.

E3.4.2 Endangered Species Act of 1973

The following species that are or may be present in the Project area have been listed as threatened or endangered under the federal Endangered Species Act: Lost River sucker (*Deltistes luxatus*), endangered; shortnose sucker (*Chasmistes brevirostris*), endangered; coho salmon (*Oncorhynchus kisutch*), threatened; bald eagle (*Haliaeetus leucocephalus*), threatened; and northern spotted owl (*Strix occidentalis caurina*), threatened. The presence and use of ESA-listed species in the Project area are discussed in more detail for aquatic species in Section E4 (Fish Resources) and for terrestrial wildlife species in Section E5 (Botanical and Wildlife Resources) of this Exhibit E.

E3.4.3 Wild and Scenic Rivers Act

Eleven miles of the Klamath River from the J.C. Boyle powerhouse to the California-Oregon border are designated as a scenic river under Section 2(a)(ii) of the federal Wild and Scenic Rivers Act (WSRA). The Klamath River from 3,600 feet below Iron Gate dam to its mouth, a reach extending approximately 190 miles, is also designated under Section 2(a)(ii). These designations are based on the outstanding remarkable values (ORVs) of fisheries, recreation, scenic quality, prehistory, history, Native American traditional uses, and wildlife.[17]

Under the Section 2(a)(ii) designation, the Klamath River remains in local and state management. This provision of the WRSA specifically precludes federal acquisition or management, except for those lands already in the public domain. (However, land exchanges by federal agencies are allowed under Section 2(a)(ii), and purchases under other land management plans can also occur.) BLM administers most of the public lands in the river corridor. The Klamath River also includes a segment beginning at the Oregon-California border and extending to Copco reservoir that was determined to be eligible for "Scenic" designation in the Scenic Waterways System. Although not yet designated, federal lands in this reach are currently managed by BLM to maintain the ORVs that qualified the segment for Scenic status. The proposed management alternative emphasizes enhancement of resource values for which the river was designated a

[17] Klamath Wild and Scenic River Eligibility Report and Environmental Assessment. National Park Service. Pacific Northwest Region, August 1994.

Scenic river. The goal of this alternative is to maintain all ORVs, while placing emphasis on restoration and enhancement of the values related to natural resources. Proposed actions are designed to achieve this goal and not create any significant resource management conflicts with other ORVs.

E3.4.4 Land and Resource Management Plans

E3.4.4.1 Bureau of Land Management Resource Management Plans

The Federal Land Policy and Management Act (FLPMA) requires BLM to develop resource management plans with public input. In April 2003, BLM issued a Draft Upper Klamath River Management Plan Environmental Impact Statement and Resource Management Plan Amendments. These documents outline management options and environmental consequences for managing lands administered by BLM along the upper Klamath River, including in the Project area. Once final, the Draft River Management Plan is intended to amend BLM Resource Area resource management plans for the area.

E3.4.4.2 U.S. Forest Service Klamath National Forest Resource Management Plans

The Forest and Rangeland Renewable Resources Planning Act (FRRPA) requires each National Forest supervisor to develop a plan that directs management activities on National Forests. The Klamath National Forest is the nearest National Forest to the Project, but it is not within the Project area. The Klamath National Forest contains lands along the lower Klamath River, between about RM 45 (near the confluence with Trinity River) and RM 175 (near the confluence with the Shasta River), about 15 miles downstream of Iron Gate reservoir.

E3.4.4.3 Aquatic Conservation Strategy Standards and Guidelines

Lands administered by BLM and the Klamath National Forest are located within the implementation range of the Northwest Forest Plan. Central to the Northwest Forest Plan is the Aquatic Conservation Strategy (ACS). The ACS was developed to restore and maintain the ecological health of watersheds and aquatic ecosystems contained within them. Nine objectives are central to the ACS:

1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations, and communities are uniquely adapted.
2. Maintain and restore spatial and temporal connectivity with and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia.
3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configuration.
4. Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

5. Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.
6. Maintain and restore instream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain pattems of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.
7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.
8. Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.
9. Maintain and restore habitat to support well-distributed populations of native plants and invertebrate and vertebrate riparian-dependent species.

The Standards and Guidelines (S&Gs) developed to ensure that management actions are implemented consistently with the ACS include several relating to hydropower relicensing.

- LH-l requires identification of “in-stream flows needed to maintain riparian resources, channel conditions, and fish passage” and applies to new and/or existing hydropower projects.
- LH-2 distinguishes between relicensing projects in Tier 1 Key Watersheds[18] and relicensing in other watersheds and whether a project is a new proposal or involves relicensing of an existing project. The specific S&Gs for existing projects in Tier I Key Watersheds require license conditions “. . .that require flow and habitat conditions that maintain or restore riparian resources and channel integrity.” The S&Gs for existing projects in all other watersheds require license conditions that “. . .emphasize in-stream flows and habitat conditions that maintain or restore riparian resources and channel integrity.”
- LH-3 addresses impacts for projects located within riparian reserves. LH-3 refers to existing facilities within riparian reserves “that are essential to proper management” and that require recommendations from BLM to FERC to ensure that facility operation will be consistent with ACS objectives. Existing facilities that must be located in riparian reserves will be located, operated, and maintained to eliminate effects that retard or prevent attainment of ACS objectives.
- WR-1 addresses design and implementation of watershed restoration projects in a manner that promotes long-term ecological integrity of ecosystems, conserves the genetic integrity of native species, and attains ACS objectives.

[18] An important component of the ACS is designation and management of Key Watersheds. This designation overlays all land allocations. Tier 1 watersheds are designated for sensitive fish stocks or poor watershed condition, and are a priority for watershed restoration. Two Tier I Key Watersheds occur in the Project vicinity: Jenny Creek (including Spring Creek) and Spencer Creek.

- FW-1 addresses design and implementation of restoration and enhancement activities in a manner that contributes to meeting ACS objectives.

- FW-4 identifies cooperation with federal, tribal, and state fish management agencies to identify and eliminate impacts associated with habitat manipulation, fish stocking, harvest, and poaching that threaten the continued existence and distribution of native fish stocks.

E3.4.5 Oregon Department of Fish and Wildlife Policies Related to Water Use and Quality

ODFW has established a Klamath Basin Fish Management Plan (OARs 635-500-3600 through -3860) that addresses the protection and promotion of natural production of indigenous species, and protection and restoration of their habitats through coordination and cooperation with other agencies, entities and landowners. Objective 5 of the Habitat Management Policies and Objectives in the Klamath Basin Fish Management Plan is to protect and restore water quality throughout the Klamath Basin as it relates to the maintenance of fish resources.

E3.4.6 California Department of Fish and Game Policies Related to Water Use and Quality

CDFG has several policies directed at the management of fish and wildlife populations. Since 1974, CDFG has managed a 6-mile reach of the Klamath River upstream of Copco reservoir as a wild trout area. CDFG is in the process of finalizing an updated management plan for this area. Three specific water quality goals are included among the various management goals listed in the updated plan:

- Water temperatures are not to exceed 70°F and not to exceed 60°F for longer than 12 hours.

- Water transparency and suspended sediment loading are not to exceed standards set by NCRWQCB (1994).

- The river is to be free of any pollutant that could negatively impact the fishery or detract from the aesthetic value of the wild trout area.

E3.4.7 Klamath River Basin Compact

In 1957, Oregon and California adopted, and the U.S. Congress ratified, the Klamath River Basin Compact. P.L. 85-222; *see also* ORS 542.610 to 542.630. Among other things, the compact establishes certain priorities for water rights acquired after the adoption of the compact and establishes a bi-state commission to facilitate interstate cooperation and administer the compact.

E3.5 REVIEW OF EXISTING CONDITIONS WITH APPLICABLE WATER QUALITY STANDARDS

This section provides a description of current water quality conditions in the proposed Project area in the context of applicable water quality standards or objectives (as summarized in Table E3.4-1). As described in sections E3.2 and E3.3, there are several sources that contribute to water quality conditions in the proposed Project area. During much of the year, water entering the Upper Klamath River from Upper Klamath Lake carries a high load of nutrients and organic matter. In addition, water entering from the Klamath Straits Drain and Lost River diversion channel has high concentrations of nitrogen, phosphorus, low dissolved oxygen, and BOD. Other inputs, such as from municipal wastewater treatment and industrial facilities, add to the nutrient and organic load. As the river flows through the Project area, water quality is further affected by retention and stratification processes in Project reservoirs, as well as diversion or fluctuation of flow in Project-affected river reaches.

The states of Oregon and California have determined that current water quality conditions do not meet water quality standards or objectives at certain times and locations. The Klamath River from Keno dam to the California border, including J.C. Boyle reservoir, is included on the 303(d) list by ODEQ for water temperature (summer) (Table E3.4-1). The Klamath River from Stateline to Iron Gate dam is included on the 303(d) list by the state of California for nutrients, water temperature, and organic enrichment/low dissolved oxygen.

Historical data (as discussed in section E3.2) do not indicate any significant trends in water quality conditions over recent years. It can therefore be assumed that the current conditions will reflect future water quality conditions under a new license, absent enhancement measures. (Section E3.8 provides descriptions of measures proposed by PacifiCorp to enhance current water quality conditions.)

E3.5.1 Water Temperature

E3.5.1.1 Applicable Oregon Water Quality Standard[19]

OAR 340-041-0028(4)(e) – The 7-day average of daily maximum temperatures of a stream designated for redband trout use may not exceed 20°C. All Oregon waters potentially affected by the Project are designated for redband trout use except the Klamath River between Upper Klamath Lake and Keno dam.

OAR 340-041-0028(9) – Waters designated for cool water species may not be warmed by more than 0.3°C above the ambient conditions unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life.

E3.5.1.2 Applicable California Water Quality Objective

Elevated temperature waste discharges into COLD interstate waters are prohibited. In addition, the following temperature objectives apply to surface waters:

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

19 Oregon and California water quality standards are not quoted verbatim in this section. For the complete text of the rules refer to OAR Chapter 340, Division 041, and the North Coast Regional Water Quality Control Board Water Quality Control Plan for the North Coast Region.

E3.5.1.3 Review of Existing Conditions with Water Temperature Standards

Oregon

The Klamath River in the proposed Project area from Keno dam to the California border is designated for redband trout, requiring temperatures (measured as the 7-day average of daily maximum temperatures) to not exceed 20°C. Temperatures in the Klamath River between Keno dam and the California border exceed 20°C during the summer (Figure E3.5-1), as a consequence of naturally warm water above Keno dam, which determines the temperature in the river below Keno. Seven-day average daily maximum daily temperatures in Keno reservoir exceed 20°C for several months each summer (Figure E3.5-1). Water temperature in the Klamath River tends to decrease after leaving Keno reservoir (Figures E3.5-1 and E3.5-2, top panel).

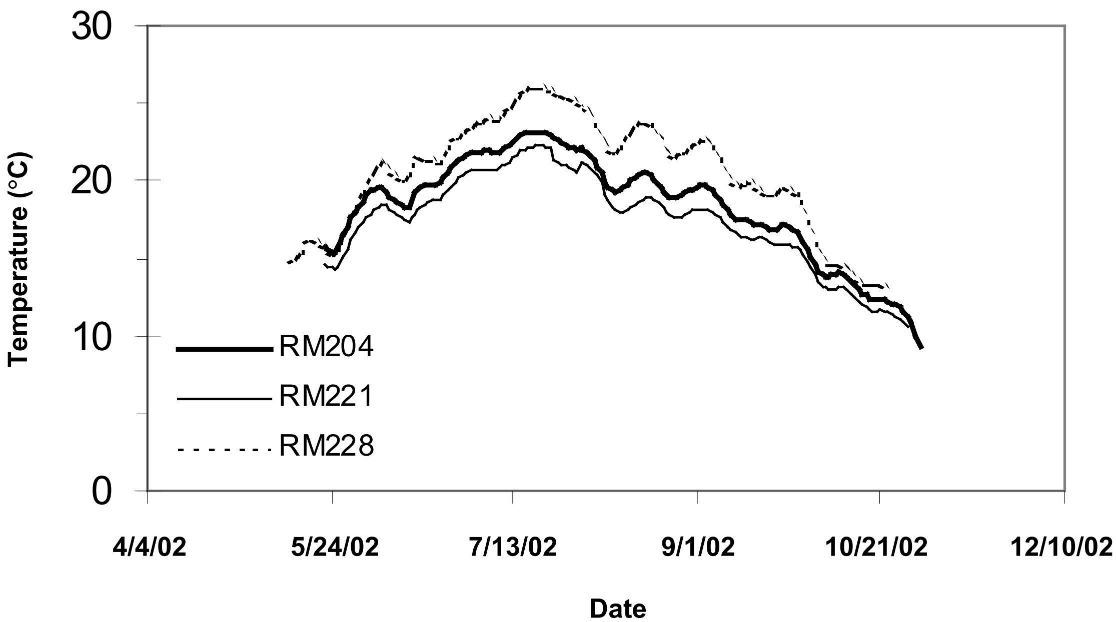
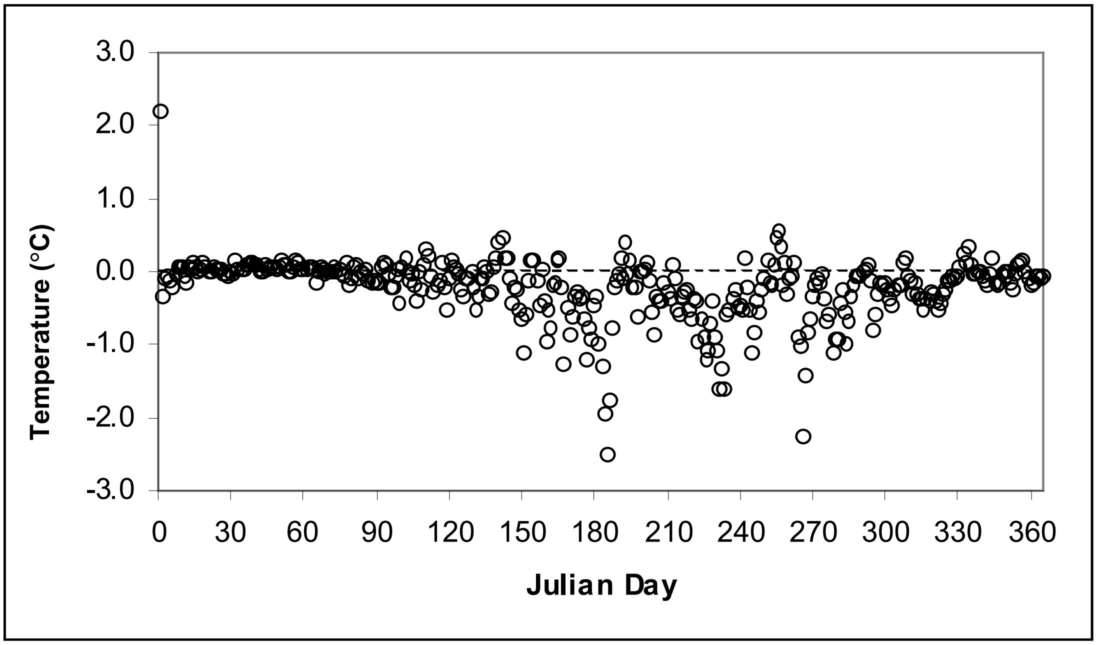


Figure E3.5-1. Seven-day average daily maximum temperature measured in the Klamath River just above J.C. Boyle reservoir (RM 228), at the USGS gauge below J.C. Boyle Dam (RM 221), and at the California border (RM 204). The temperatures reflect the influence of cool groundwater above RM 221 and subsequent natural warming.

ODEQ has included the Klamath River from RM 207 to RM 231 (below Keno dam) and from RM 250 to RM 251 (Link River) on the 303(d) list of water-quality-impaired water bodies on the basis of summer temperatures in excess of the formerly applicable 17.8°C salmonid rearing criterion. In addition, ODEQ has listed the Klamath River from RM 231 to RM 250 (from Lake Ewauna to Keno dam) on the basis of a former temperature criterion that prohibited temperature increases when dissolved oxygen criteria were not met or were just met.

The water entering the Project area from Keno reservoir (via the Keno reach) is generally in equilibrium with ambient climatic conditions, although the temperature of water leaving Upper Klamath Lake and Keno reservoir may lag short-term weather changes. Keno reservoir is exposed to sun and wind, and there are few anthropogenic sources of heat load to the Klamath

River. There appears to be little that influences temperature in the Klamath River between Link dam and Iron Gate dam other than ambient climatic conditions.



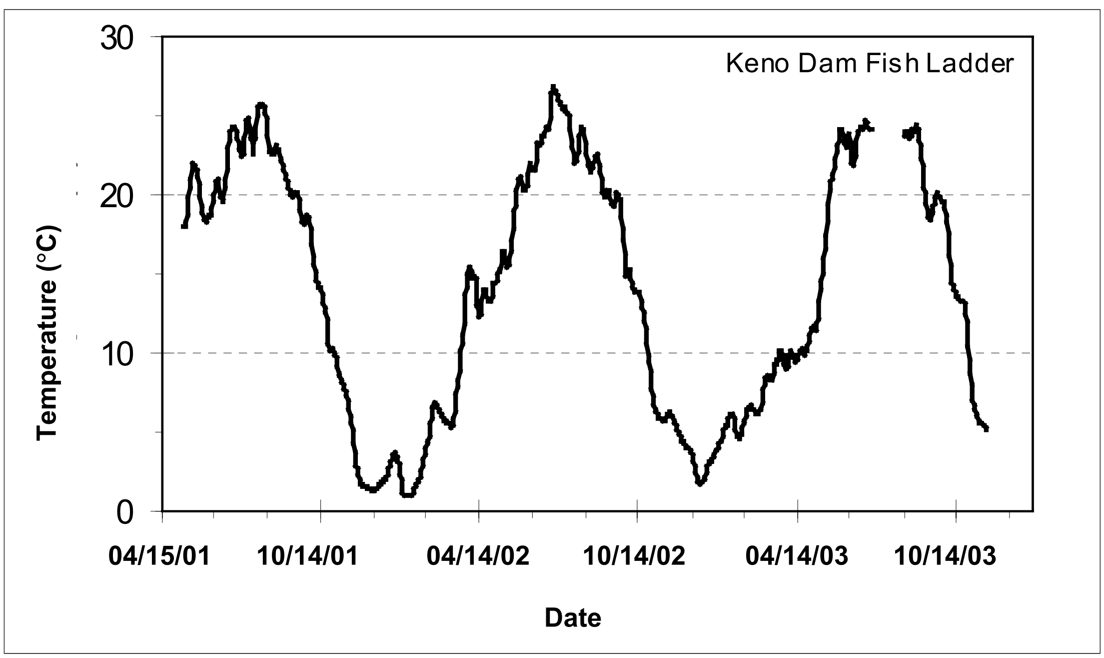


Figure E3.5-2. Top panel: Temperature difference between Keno dam and above J.C. Boyle reservoir under existing conditions. Values less than zero indicate that water temperature above J.C. Boyle is cooler than at Keno dam. Bottom panel: 7-day mean maximum temperature measured at Keno dam.

Based on results from PacifiCorp's water quality models (see the Water Resources FTR, Section 4.0), a comparison of the simulated 7-day average of daily maximum temperature in the Klamath River at J.C. Boyle dam (RM 224.5) under existing conditions (based on 2000 conditions) and a hypothetical without-Project scenario is shown in Figure E3.5-3. Temperature shows a similar pattern in response to meteorological conditions under both scenarios. For most of the year, the 7-day average daily maximum temperature under existing conditions is similar to or lower than the without-Project scenario, showing that the reservoir acts to moderate daily maximum temperature.

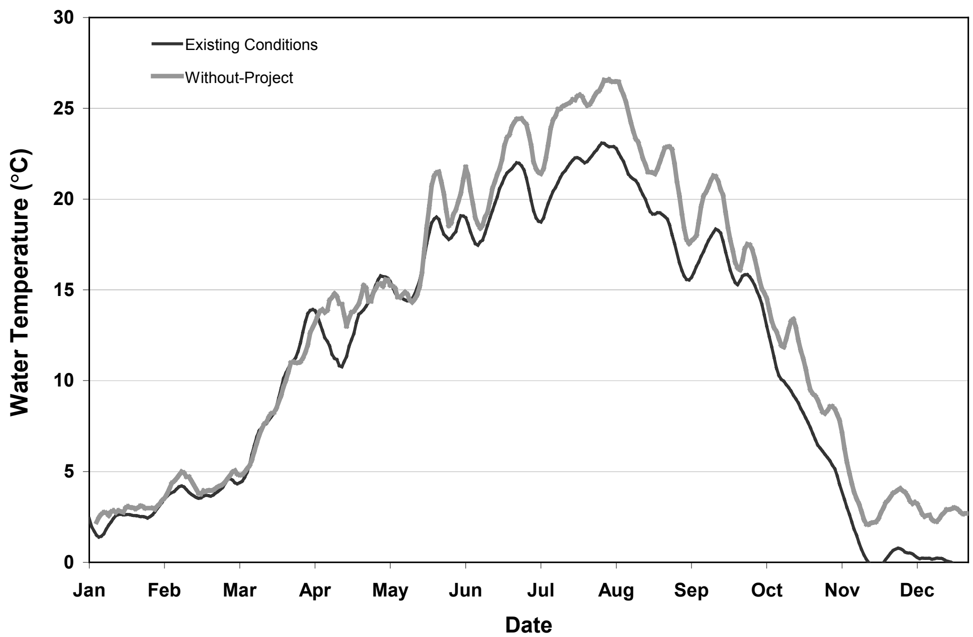


Figure E3.5-3. Seven-day average daily maximum temperature in the Klamath River at J.C. Boyle dam (RM 224.3) under existing conditions in 2000 compared to a hypothetical without-Project scenario.

A similar water quality model comparison of the simulated 7-day average of daily maximum temperature in the Klamath River in the J.C. Boyle bypass reach above the powerhouse (RM 221) under existing conditions (based on 2000 conditions) and a hypothetical without-Project scenario is shown in Figure E3.5-4. The dominant influence of the 225 cfs of spring flow accretion in the bypass reach is notable under existing conditions, allowing cooler water temperatures (below about 17.5°C) to prevail throughout the summer. In the J.C. Boyle peaking reach below the powerhouse (RM 220), the 7-day average daily maximum temperature under existing conditions is similar to or lower than the without-Project scenario, reflecting the effects of powerhouse flow releases (Figure E3.5-5). By the time flows have traveled through the J.C. Boyle peaking reach to just above Copco reservoir (RM 204), daily maximum temperature under existing conditions are similar to the without-Project scenario (Figure E3.5-6).

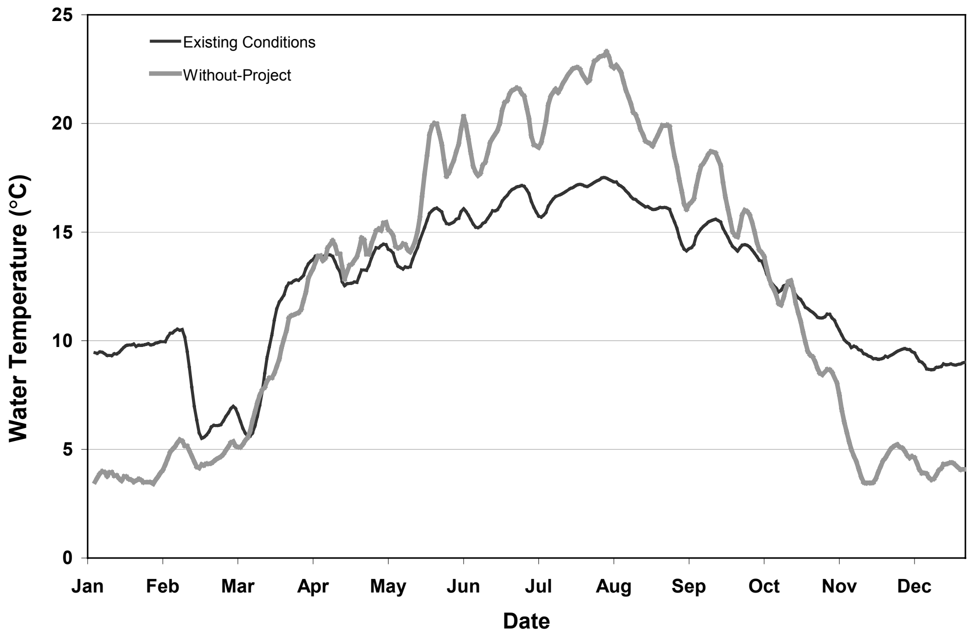


Figure E3.5-4. Seven-day average daily maximum temperature in the J.C. Boyle bypass reach just above the powerhouse (RM 221) under existing conditions in 2000 compared to a hypothetical without-Project scenario.

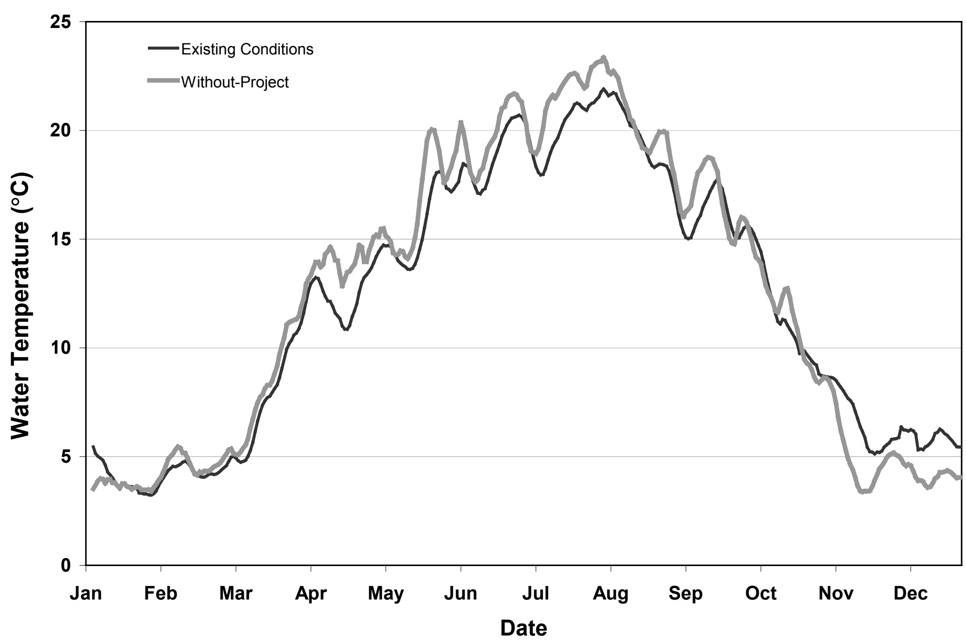


Figure E3.5-5. Seven-day average daily maximum temperature in the J.C. Boyle peaking reach just below the powerhouse (RM 220) under existing conditions in 2000 compared to a hypothetical without-Project scenario.

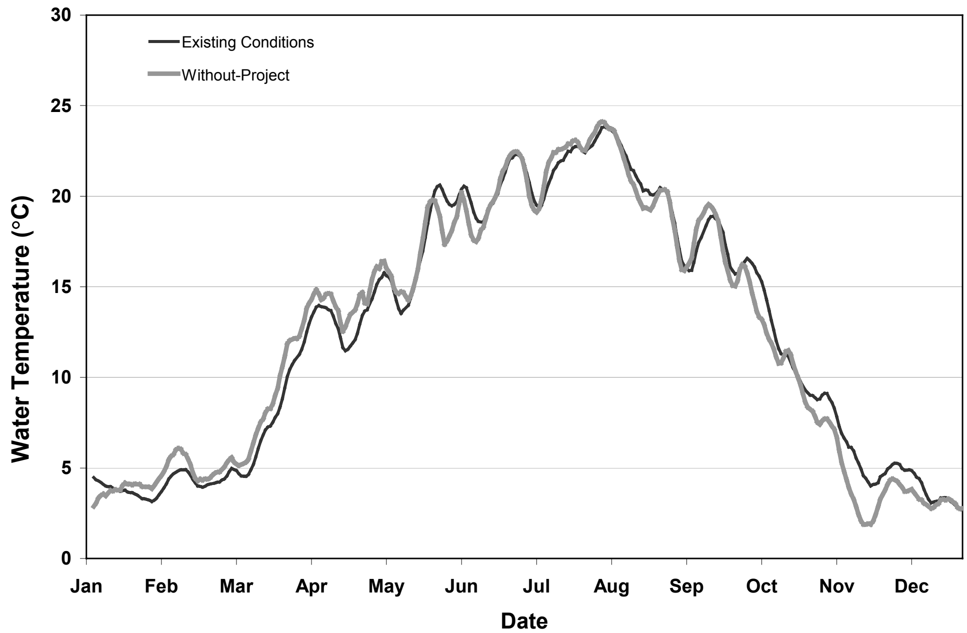


Figure E3.5-6. Seven-day average daily maximum temperature in the J.C. Boyle peaking reach just above Copco reservoir (RM 204) under existing conditions in 2000 compared to a hypothetical without-Project scenario.

California

California identifies the Klamath River from the Oregon border as warm-water, cold-water, and wild trout habitat. The state has included the reach of the river from the Oregon border to the Scott River on the 303(d) list of water-quality-limited water bodies based on water temperature.

California water quality objectives state that water temperature may be increased only if it can be demonstrated that beneficial uses are not adversely affected, and that no temperature increase can exceed 5°F (2.8°C). Modeling to date has shown that the Klamath River above Iron Gate reservoir is generally in equilibrium with climatic conditions, and that temperatures do not vary significantly from Keno dam to Copco reservoir. Reservoirs, by virtue of their large thermal mass, tend to dampen and delay changes in temperature.

Water temperatures in Copco and Iron Gate reservoirs follow a pattern that is typical of lakes in the Pacific Northwest. Most lakes east of the Cascade Mountains achieve temperatures in excess of 20°C near the surface during the summer while maintaining temperatures near 8° or 10°C when stratified. Because water entering Copco and Iron Gate reservoirs during the winter is near 4°C, and because the outlets of both Copco and Iron Gate reservoirs are relatively shallow, cooler water temperatures are maintained at depth.

Figure E3.5-7 presents the daily average temperature measured in Link River and below Iron Gate dam. Temperatures in Link River and below Iron Gate dam are similar from February to October, with allowances made for the greater variability in Link River. Beginning in October, temperatures in Link River and below Iron Gate dam begin to diverge, reaching a maximum difference in late November. This divergence is a consequence of the thermal stratification of Iron Gate and the time required to cool and mix Iron Gate reservoir. During the period from

October to February, the Klamath River below Iron Gate dam is warmer than it would otherwise be. This difference can exceed 5°F (2.8°C) in November and December.

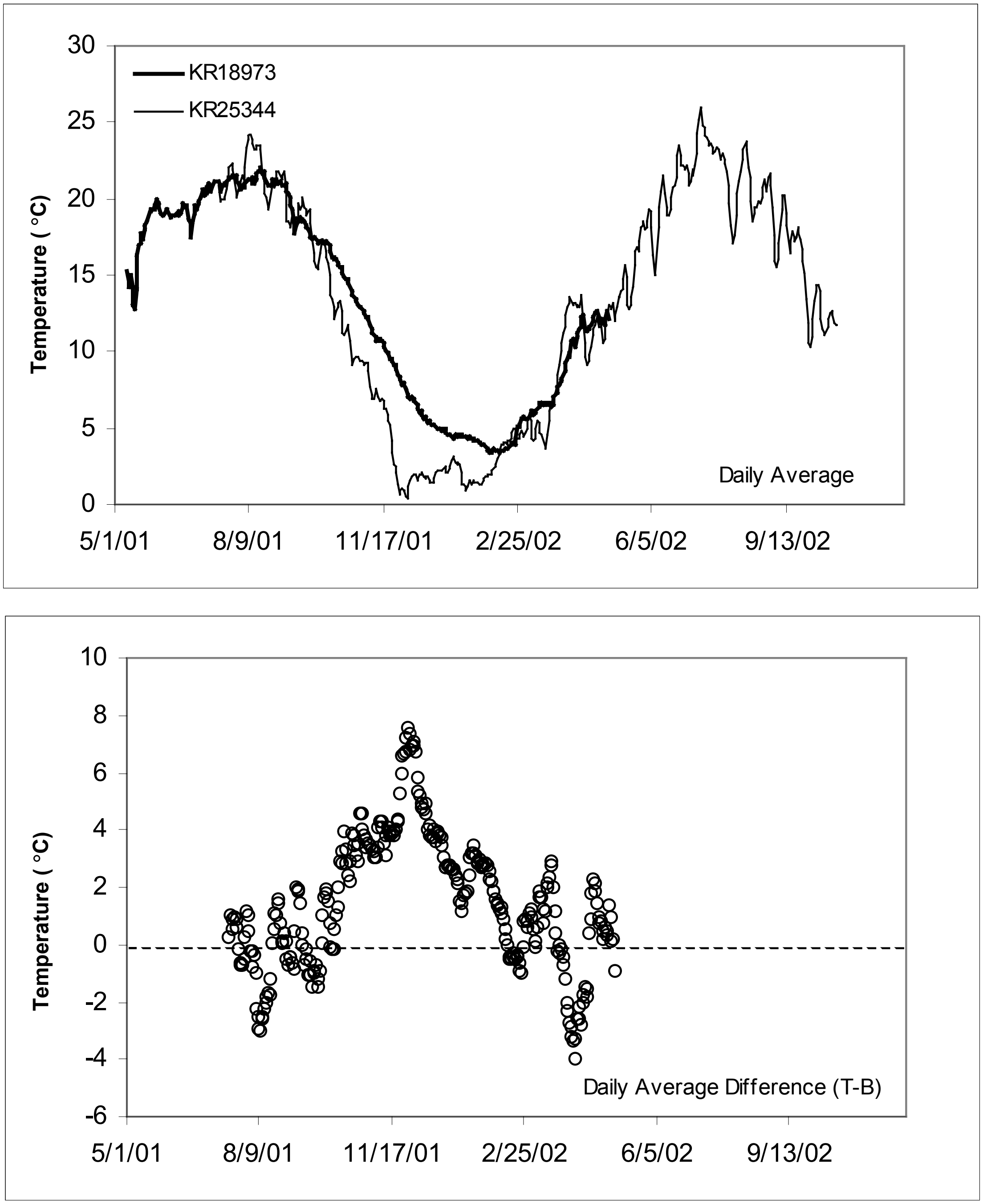


Figure E3.5-7. Daily average temperature (top) measured in the Link River below Link dam (KR25344) and in the Klamath River below Iron Gate dam (KR18973), and the difference in daily average temperature between the two sites (bottom).

E3.5.2 Dissolved Oxygen

E3.5.2.1 Applicable Oregon Water Quality Standard (OAR 340-041-0016)

For active spawning areas, dissolved oxygen may not be less than 11.0 mg/L during the applicable spawning through fry emergence period. However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 mg/L or greater, then the dissolved oxygen criterion is 9.0 mg/L. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0 mg/L or 9.0 mg/L criteria, dissolved oxygen levels must not be less than 95 percent of saturation.

For water bodies identified as providing cold-water aquatic life, dissolved oxygen may not be less than 8.0 mg/L as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/L, dissolved oxygen levels must not be less than 90 percent of saturation. Where adequate information exists to document levels, dissolved oxygen may not fall below 8.0 mg/L as a 30-day mean minimum, 6.5 mg/L as a 7-day minimum mean, and 6.0 mg/L as an absolute minimum.

For water bodies identified as providing cool-water aquatic life, dissolved oxygen may not be less than 6.5 mg/L as an absolute minimum. Where adequate information exists, dissolved oxygen may not fall below 6.5 mg/L as a 30-day mean minimum, 5.0 mg/L as a 7-day minimum mean, and 4.0 mg/L as an absolute minimum.

E3.5.2.2 Applicable California Water Quality Objective

In the Middle Klamath River Hydrologic Area, dissolved oxygen in the Klamath River above Iron Gate dam, including Iron Gate and Copco reservoirs, shall not be reduced below 7.0 mg/L at any time. Fifty percent of the monthly mean values for a calendar year must be greater than or equal to 10.0 mg/L.

In the Klamath River below Iron Gate dam, dissolved oxygen shall not be reduced below 8.0 mg/L at any time. Fifty percent of the monthly mean values for a calendar year must be greater than or equal to 10.0 mg/L.

E3.5.2.3 Review of Existing Conditions with Dissolved Oxygen Standard

Oregon

Oregon has designated the Klamath River from Keno dam to the California border to support Lahontan cutthroat and redband trout. Trout have only been observed spawning in the mainstem Klamath River within the Project area in the lower end of the J.C. Boyle bypass reach. Spawning does occur in Shovel and Spencer creeks. In the Klamath River below Keno dam to the California border, where the current velocity is high and re-aeration is more effective, dissolved oxygen is generally near saturation. Dissolved oxygen concentration at 100 percent saturation is less than 11 mg/L at the altitudes and temperatures that occur in the Project area. Figure E3.5-8 shows the values of dissolved oxygen, as percent saturation at sea level, compared to the 95 percent saturation level at the elevation of the individual sites. Most measured values are above the 95 percent saturation level. With the exception of J.C. Boyle reservoir, all but one measured value would exceed the local 90 percent saturation level. More than half of the dissolved oxygen values less than 8 mg/L were recorded in J.C. Boyle reservoir, a result of dissolved oxygen depletion at depth in the reservoir.

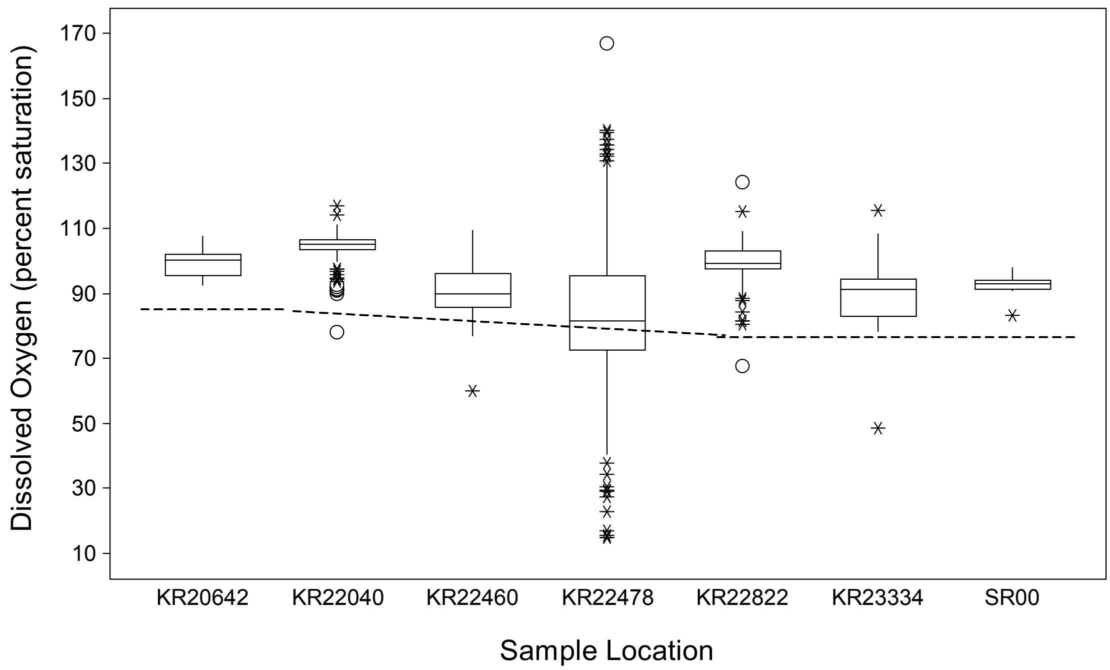


Figure E3.5-8. Distribution of values of dissolved oxygen, as percent saturation at sea level, measured at sites in the Klamath River in 2000 through 2003. The dashed line shows the approximate 95 percent saturation level at the elevation of the individual sites. Sites in the Klamath River are: KR20642 – upstream of Shovel Creek, KR22040 – bottom of J.C. Boyle bypass reach, KR22460 – below J.C. Boyle dam, KR22478 – J.C. Boyle reservoir, KR22822 – above J.C. Boyle Reservoir, KR23334 – below Keno dam, SR00 – Shovel Creek.

<u>California</u>

California has designated the Middle Klamath River Hydrologic Area to support COLD water habitat, but has identified more stringent specific water quality objectives for the hydrologic area. Summary values for dissolved oxygen measured in 2000 through 2003 are listed in Table E3.5-2.

California has included the Klamath River (above and including Copco and Iron Gate reservoirs) on the 303(d) list based on an absolute minimum value of 7.0 mg/L and a 50 percentile lower limit of 10 mg/L (based on monthly mean values). The Klamath River mainstem below Iron Gate dam to the mouth is included, based on an absolute minimum value of 8.0 mg/L and a 50 percentile lower limit of 10 mg/L.

As indicated in Table E3.5-2, the concentration of dissolved oxygen in Copco and Iron Gate reservoirs is influenced by depth. This relationship is illustrated for Iron Gate reservoir in Figure E3.5-9. The pattern of dissolved oxygen seen in Copco and Iron Gate reservoirs is typical of highly productive, stratified lakes and reservoirs where the loss of oxygen in the hypolimnion results mainly from the biological oxidation of organic matter. The pattern is a function of the high productivity of the water bodies. It is a natural consequence of the high nutrient concentration in the waters entering the Project area from Upper Klamath Lake and Klamath Straits Drain.

Table E3.5-2. Summary values for dissolved oxygen measured at various locations in the Project area in 2000 through 2003. The 50th percentile represents the median of all values.

Site	Minimum (mg/L)	50th percentile (mg/L)
KR17600 – Klamath River above Shasta	8.2	10.7
KR18973 – Iron Gate Dam Outflow	5.9	8.6
KR19019 (all depths) – Iron Gate Reservoir near Dam	0.0	6.1
KR19019E*	1.9	9.3
KR19019M	0.1	6.0
KR19019H	0.0	3.8
KR19645– Klamath River above Iron Gate Dam	6.0	8.38
KR19874 (all depths) – Copco Reservoir near Dam	0.1	7.9
KR19874E	0.1	9.2
KR19874M	0.1	6.5
KR19874H	0.1	1.1
KR20642 – Klamath River above Shovel Creek	7.2	9.8

* E = values measured in the epilimnion, from 0 to 10 m depth.
M = values measured in the metalimnion, from 10 to 20 m in depth.
H = values measured in the hypolimnion, deeper than 20 m.

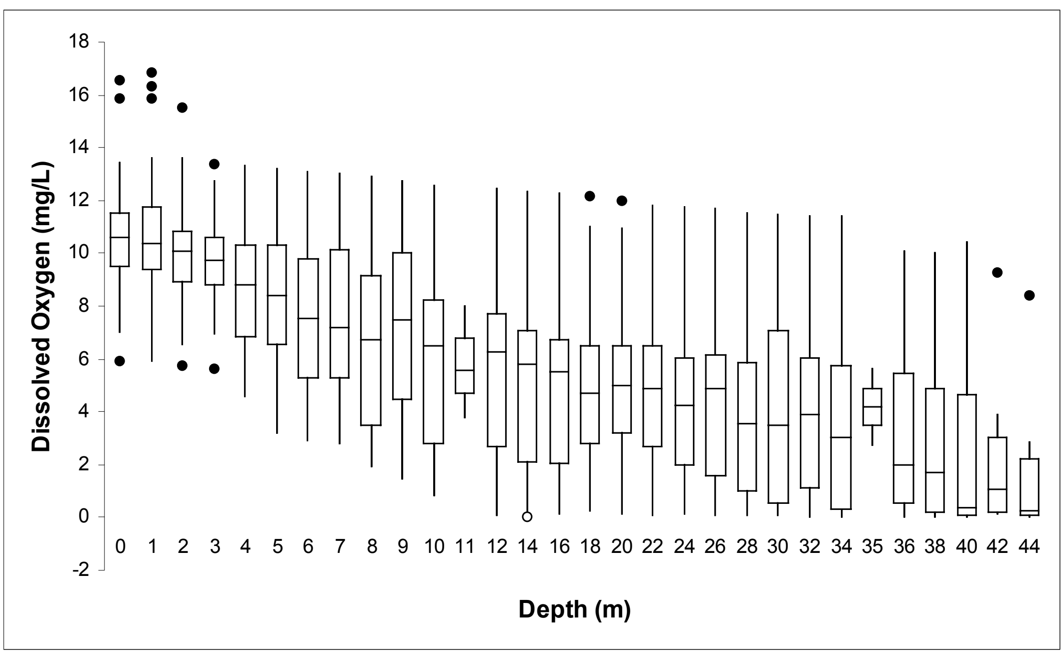


Figure E3.5-9. Distribution of dissolved oxygen values measured at various depths in Iron Gate reservoir during 2000 through 2002.

E3.5.3 Hydrogen Ion Activity (pH)

E3.5.3.1 Applicable Oregon Water Quality Standard

Under OAR 340-041-0185(1)(a), pH may not fall outside the range of 6.5 to 9.0. Under OAR 340-041-0021(2), waters impounded by dams existing on January 1, 1996, which have pH that exceeds the criteria are not in violation of the standard if ODEQ determines that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria.

E3.5.3.2 Applicable California Water Quality Objective

For waters in the Middle Klamath River Hydrologic Area, the pH shall not be depressed below 7.0 or raised above 8.5.

Changes in normal ambient pH levels shall not exceed 0.5 units within the range specified above in freshwaters with designated COLD or WARM beneficial uses.

E3.5.3.3 Review of Existing Conditions with pH Standard

Oregon

According to measurements obtained in 2000 through 2003, pH exceeds 9.0 at least once in each reach of the Klamath River between Link River dam and Copco reservoir, except for the J.C. Boyle peaking reach (Table 3.5-3). Only the J.C. Boyle peaking reach had no pH value less than 6.5 or greater than 9.0. The free-flowing reach between Keno dam and J.C. Boyle reservoir had no pH value less than 6.5.

Table E3.5-3. Summary of pH values measured in the Klamath River in Oregon between Link dam and Copco reservoir in 2000 through 2003.

River Reach	N	Percent < 6.5	Percent > 9.0
Link River	153	0.6	32.7
Keno Reservoir	497	0.2	5.4
Keno Dam to J.C. Boyle Reservoir	114	0	4.4
J.C. Boyle Reservoir	438	1.1	1.1
J.C. Boyle Bypass Reach	211	0.9	1.4
J.C. Boyle Peaking Reach	65	0	0

Elevated pH occurs in productive lakes and rivers as a result of photosynthetic activity. Chlorophyll *a* concentrations in the Klamath River are high—average values for many sites exceed 15 µg/L in June through October. High rates of photosynthesis deplete the dissolved carbon dioxide in the water, which results in an increase in pH. This effect is particularly notable in Link River and Keno reservoir, which determine the quality of water entering the proposed Project area, where the high chlorophyll content in water coming from Upper Klamath Lake often results in pH values in excess of 9.0.

Oregon DEQ has included the Klamath River from RM 231 to RM 251 (Keno reservoir) on the 303(d) list of water-quality-impaired water bodies based on pH exceeding the applicable pH range of 6.5-9.0.

California

In the Klamath River from the California border to the Shasta River, 9.7 percent of pH values exceed 8.5 and 8.3 percent are less than 7.0 (N = 1,802). Episodes of pH greater than 8.5 occur in March through November. Values of pH less than 7.0 occur in April through October. Values of pH outside the acceptable range occur in both the reservoirs and in the Klamath River below the reservoirs (Table E3.5-4). High pH values in the reservoirs are largely limited to the epilimnion (surface layer) during the summer (Figure E3.5-10). Both Copco and Iron Gate reservoirs have their outlet at a depth that draws water from the epilimnion. Consequently, the pH in the river immediately below the reservoirs tends to be similar to that found in the reservoir epilimnion. An exception is site KR17600, just upstream from the Shasta River. Chlorophyll *a* at this site is relatively low (mean = 8.1 µg/L, maximum = 27 µg/L), but pH is still high (mean = 8.6, maximum = 9.1). It is likely that the photosynthetic production in the river has changed from one dominated by planktonic organisms to one dominated by attached organisms, which were not sampled by the chlorophyll *a* protocol.

Table E3.5-4. Summary of pH values measured in the Klamath River in California between the Oregon border and the Shasta River in 2000 through 2003.

River Reach	N	Minimum	Percent < 7.0	Percent > 8.5	Maximum
Oregon Border to Copco Reservoir	65	7.2	0	15.3	9.0
Copco Reservoir	754	6.1	6.2	11.1	9.8
Copco Reservoir to Iron Gate Reservoir	19	7.4	0	5.3	8.7
Iron Gate Reservoir	912	6.2	11.1	8.2	9.9
Below Iron Gate Reservoir	45	6.8	6.7	11.1	9.2

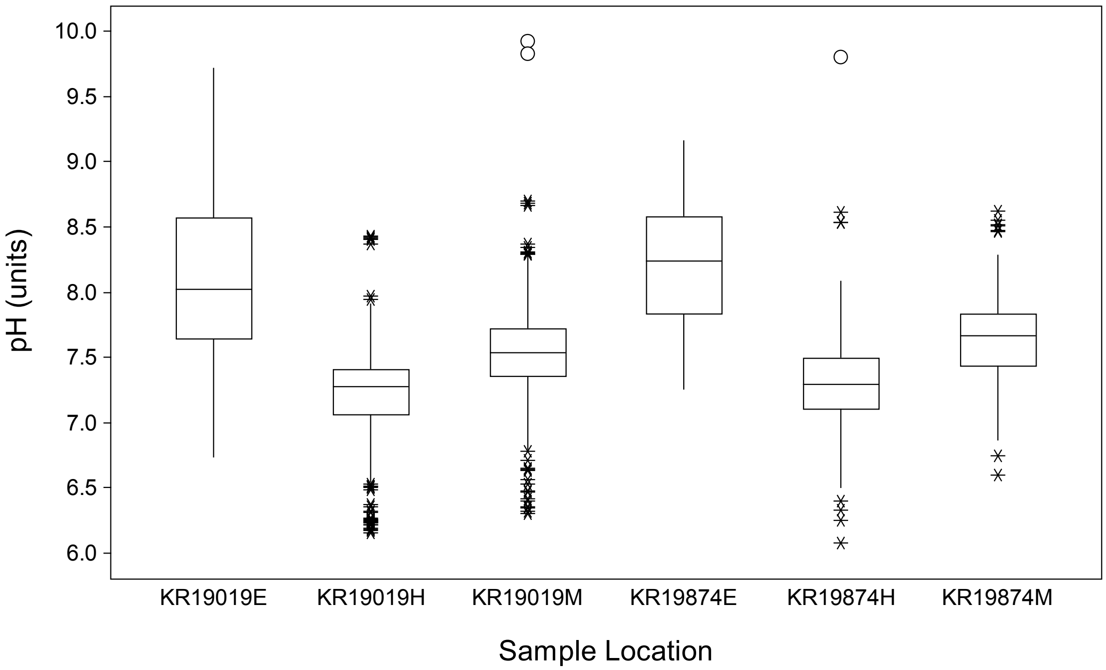


Figure E3.5-10. Distribution of pH values measured in Iron Gate and Copco reservoirs in 2000 through 2003. KR10919 – Iron Gate reservoir; KR19874 – Copco reservoir; M = metalimnion; H = hypolimnion

The pattern of pH seen in the Project reservoirs and in the Klamath River below the Project is a function of the high productivity of the water bodies. Photosynthetic activity results in elevated pH levels in the water. This occurs in Upper Klamath Lake, above the Project, in the Klamath River, and in the Project reservoirs. It is a natural consequence of the high nutrient concentration of the waters entering the proposed Project area.

E3.5.4 Nuisance Phytoplankton Growth (Oregon) and Biostimulatory Substances (California)

E3.5.4.1 Oregon Water Quality Action Level (OAR 340-041-0019)

Oregon's water quality standards include a chlorophyll *a* action level for nuisance phyto-plankton growth. In natural lakes that do not thermally stratify, reservoirs, rivers, and estuaries, the action level is 0.015 mg/L, based on a minimum of three samples collected over any three consecutive months at a minimum of one representative location from samples integrated from the surface to a depth equal to twice the Secchi depth or the bottom, whichever is less. If chlorophyll *a* values naturally exceed the action level, the action level may be modified to an appropriate value for the water body.

If the value of 0.015 mg/L or other action level is exceeded, ODEQ may conduct studies to determine the probable cause of the exceedance and its effect on beneficial uses, and develop a technically and economically practicable control strategy. Any control strategy must first be approved by the Oregon Environmental Quality Commission, although ODEQ may limit new pollutant loadings pending the completion of necessary studies if designated uses would be impaired by the new loadings.

E3.5.4.2 Applicable California Water Quality Objective

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause a nuisance or adversely affect beneficial uses.

E3.5.4.3 Review of Existing Conditions with the Nuisance Phytoplankton Growth Action Level and the Biostimulatory Substances Objective

<u>Oregon</u>

Average summer chlorophyll *a* concentrations measured during 2000 through 2003 were greater than 15 µg/L (0.015 mg/L) at all sites sampled between Upper Klamath Lake and Keno dam. The abundance of chlorophyll *a* is the result of the input of algae from Upper Klamath Lake and of the algal growth promoted by the high concentrations of nutrients entering the Project from Klamath Lake, Klamath Straits Drain, and other sources (Table E3.5-5). The concentration of nutrients in Link River and Klamath Straits drain are considerably higher than in the smaller tributaries. The smaller tributaries, flowing through lands perhaps less affected by intensive agricultural development, may more accurately represent the background concentrations. These values are, however, still considerably higher than recently recommended guidance values proposed by EPA (2000a, 2000b). The high concentration of algae in Upper Klamath Lake and Keno reservoir contributes to high chlorophyll concentration in the proposed Project area downstream.

Table E3.5-5. Average chlorophyll concentration in excess of the ODEQ action level measured between May and October in the Klamath River in 2000 through 2003 (µg/L).

Location	Site	N	Mean
Klamath River below Keno Dam	KR23334	12	27.9
Keno Reservoir at Log Boom	KR23360	5	35.6
Klamath River at Keno Bridge (Hwy. 66)	KR23490	32	20.0
Klamath River at RM 238	KR23828	14	28.3
Klamath River Upstream of Klamath Straits Drain	KR24148	14	37.9
Klamath River at Miller Island Boat Ramp	KR24589	26	38.1
Klamath River at Hwy. 140 (Southside Bypass)	KR25079	14	48.8
Link River at Mouth	KR25312	23	64.0
Link River near Powerhouse	KR25344	13	74.0
Upper Klamath Lake at Fremont St. Bridge	KR25479	3	57.5

The relative concentration of nitrogen and phosphorus in the Klamath River system suggests that phosphorus is abundant in comparison to nitrogen (Table E3.5-6). Conditions of abundant phosphorus and limited nitrogen are favorable for the growth of nitrogen-fixing cyanobacteria (blue-green algae). This is likely to happen when the ratio of nitrogen to phosphorus (by weight) is less than about 10:1 (Reynolds, 1984). The median value for N:P ratio is 7.6:1, with 70 percent of values 10:1 or less (N = 360). The seasonal changes in nitrogen and phosphorus concentration and the N:P ratio influence the algal community composition. As a consequence, the reservoirs in the Project area support seasonally dense blooms of diatoms (mostly *Asterionella formosa*) in the spring, when temperatures are cool and light is less abundant, and *Aphanizomenon flos-aquae* (a nitrogen-fixing cyanobacterium) later in the summer, when light is abundant and temperatures warmer. Seasonal changes in the concentration of nutrients in the Klamath River correspond to changes in diversions from the Klamath River to the Klamath Irrigation Project (Figure E3.5-11).

Table E3.5-6. The average concentration of nitrate nitrogen, ammonia nitrogen and total phosphorus (mg/L as the element) in water entering the Project area.

Tributary	Total P	Nitrate N	Ammonia N
Link River	0.227	0.102	0.179
Klamath Straits Drain	0.470	0.602	0.559
Spencer Creek	0.112	0.030	0.046
Shovel Creek	0.210	0.038	0.056
Fall Creek	0.154	0.065	0.058
Jenny Creek	0.105	0.025	0.055
Shasta River	0.342	0.082	0.118

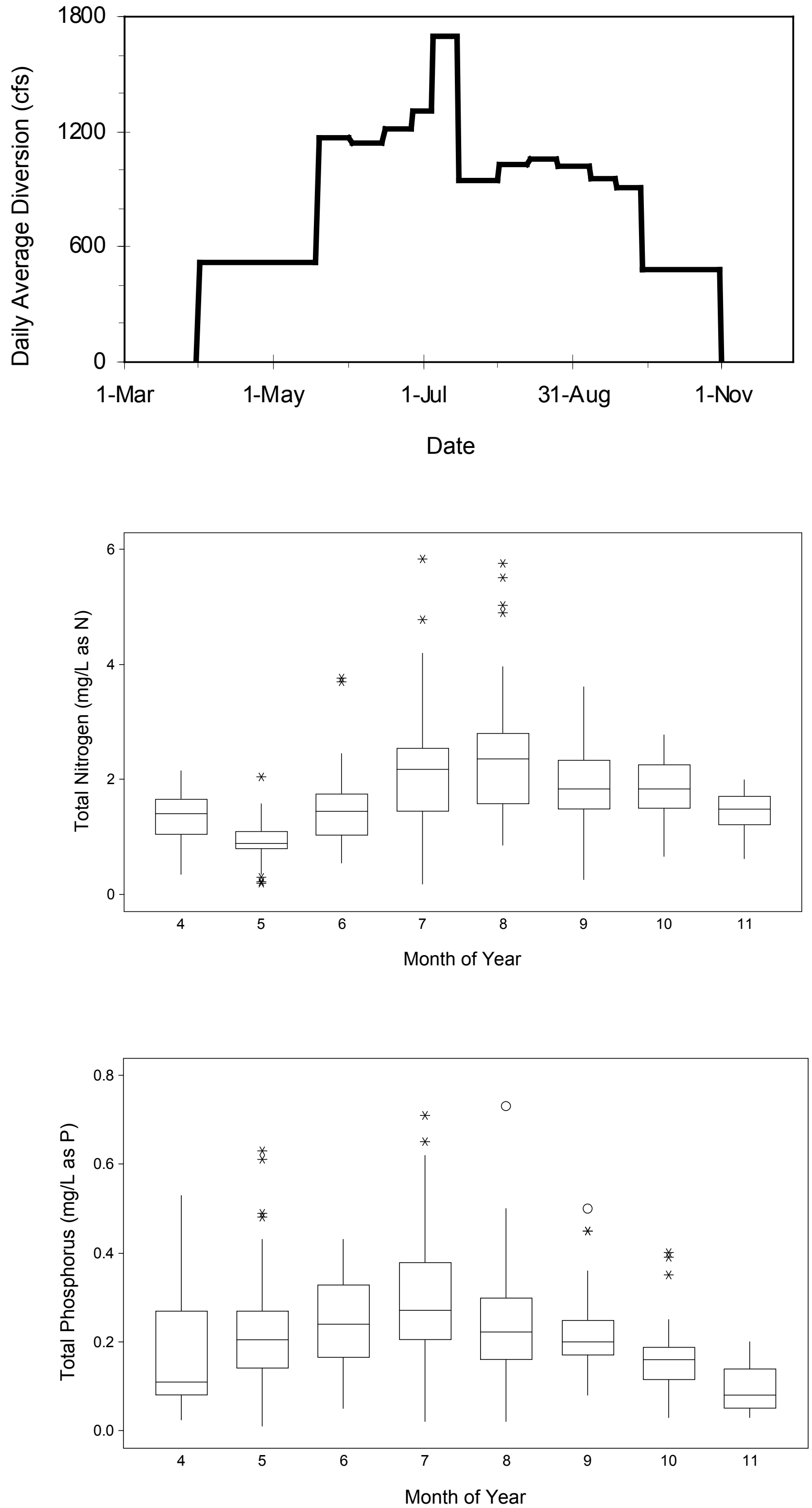


Figure E3.5-11. Seasonal changes in diversion flow to the Klamath Irrigation Project and total nitrogen and phosphorus in the Klamath River.

The Project does not cause or enable transformations in forms of nitrogen that could contribute to excess production in the Klamath River below the Project area. Data collected from 2000 through 2003 show that total nitrogen is substantially lower below Iron Gate dam than below Keno dam, and no different below Iron Gate reservoir than above Copco reservoir (Figure E3.5-12). Total phosphorus concentration decreases from J.C. Boyle reservoir to below Iron Gate reservoir. Inorganic nitrogen increases from Link River to J.C. Boyle reservoir, and then decreases to below Iron Gate dam. It appears that in the portion of the river from Link Dam to J.C. Boyle dam organic nitrogen is converted to inorganic nitrogen, and that the portion of the river within the Project area is a net sink for nutrients. High concentrations of nutrients are a consequence of high loading of nutrients from Klamath Lake and other sources.

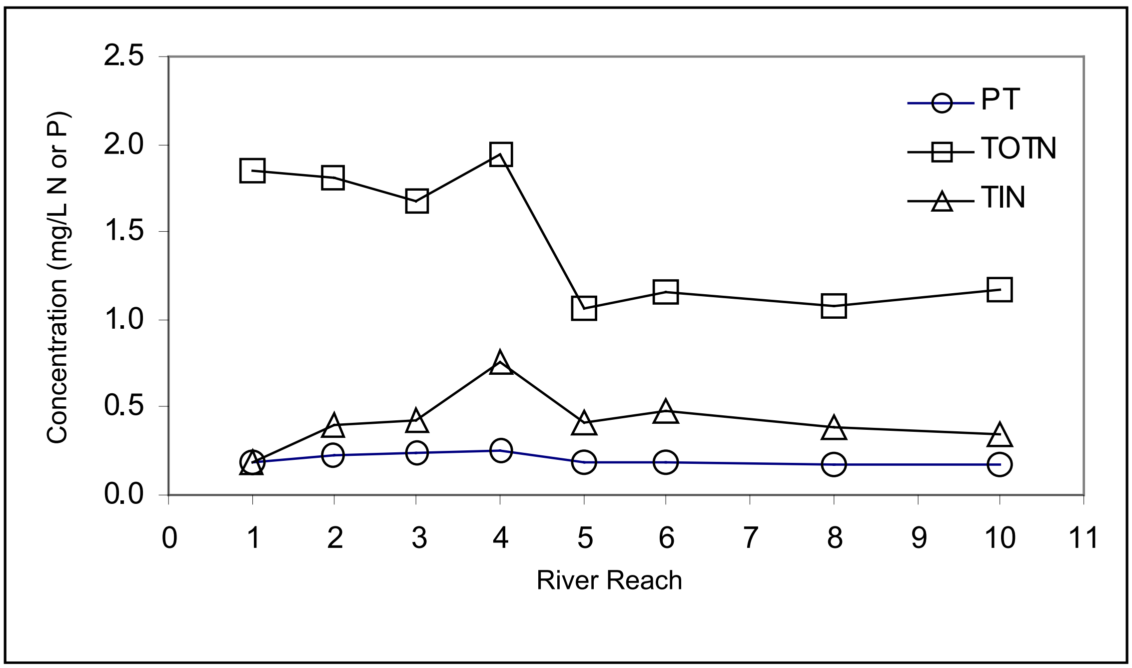


Figure E3.5-12. Change in nutrient concentration in the Klamath River between Link dam and below Iron Gate dam. Reach designations are: 1 = Link River, 2 = Keno reservoir, 3 = Keno dam to J.C. Boyle reservoir, 4 = J.C. Boyle reservoir, 5 = J.C. Boyle bypass reach, 6 = Klamath River from J.C. Boyle powerhouse to Copco reservoir, 8 = Klamath River above Iron Gate reservoir, 10 = Klamath River below Iron Gate dam to Shasta River. PT = total phosphorus, TIN = total inorganic nitrogen, TOTN = total organic nitrogen.

Chlorophyll *a* concentrations measured in the Project area exceed the ODEQ guidance value of 15 µg/L. The abundance of chlorophyll in the project waters is the result of the high concentrations of nutrients entering the Project from Upper Klamath Lake and the Klamath Irrigation Project. The relative concentration of nitrogen and phosphorus in the Klamath River system suggests that phosphorus is abundant in comparison to nitrogen. Late summer dominance by cyanobacteria (blue-green algae) often occurs in lakes and reservoirs when algal growth is limited by low concentration of nitrogen.

Some stakeholders have expressed concern that the existence of the Project reservoirs may cause or enable transformations in forms of nitrogen that could contribute to excess production in the Klamath River below the Project area. Data collected in 2000 through 2003 reveal that this is not the case. Although there is a substantial transformation of nitrogen from organic forms to inorganic forms in the Klamath River reach between Keno dam and J.C. Boyle reservoir, the concentration of all forms of nitrogen and phosphorus below Iron Gate dam is similar to or less than the concentration in the Klamath River above Copco reservoir.

E3.5.5 Total Dissolved Gas

E3.5.5.1 Applicable Oregon Water Quality Standard (OAR 340-041-0031)

(1) Waters will be free from dissolved gases, such as carbon dioxide, hydrogen sulfide, or other cases, in sufficient quantities to cause objectionable odors or to be deleterious to fish or other aquatic life, navigation, recreation, or other reasonable uses made of such water.

(2) Except when stream flow exceeds the 10-year, 7-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation. However, in hatchery-receiving waters and other waters less than 2 feet in depth, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 105 percent of saturation.

E3.5.5.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for total dissolved gas.

E3.5.5.3 Review of Existing Conditions with Total Dissolved Gas Standard

PacifiCorp conducted water quality monitoring in 2000 through 2003, including TDG measurements during periods when Project operations might be expected to lead to supersaturation. Studies also included field observations to detect the presence of other dissolved gases, such as hydrogen sulfide. No instances of the presence of objectionable odors or releases of gases were observed in 2000 through 2003.

Water can become supersaturated with atmospheric gases when plunging to depth after spill over a dam. Water is only spilled at dams in the Project area when flow coming into a Project facility is greater than powerhouse hydraulic capacity or during facility maintenance. TDG concentration was measured during spill events and maintenance events at Link dam and J.C. Boyle dam in Oregon and at Iron Gate dam in California in 2002 and 2003. No TDG measurement exceeded Oregon’s standard.

Maintenance at Link dam occurred in May 2002. TDG measurements were taken below Link River dam before and during the planned spill event. Percent saturation differed by only 3 percent between minimal (90 cfs) spill and maintenance spill. The average daily flow at Link River dam during maintenance activities was 1,134 cfs, with a maximum of 1,665 cfs and a minimum of 605 cfs. Readings were 99 and 102 percent for the minimal and full spill releases, respectively.

Maintenance was performed at J.C. Boyle dam in September 2002 and June 2003. During the 2002 event, flow in the J.C. Boyle peaking reach prior to maintenance averaged 668 cfs, with a maximum flow of 1,781 cfs and a minimum of 350 cfs, as recorded at the USGS gauge below the J.C. Boyle powerhouse. The powerhouse was operating on a single unit peaking regime, using only one of the two available turbines.

TDG measurements were taken during the September 2002 spill event at J.C. Boyle dam in two locations within the bypass reach. TDG measured 99 percent at the upper end of the bypass reach. A value of 100 percent was measured at the lower end of the bypass reach, just upstream of the powerhouse.

Spill at J.C. Boyle dam during the June 2003 maintenance activity varied between zero and 185 cfs throughout the course of monitoring. Two separate releases were made prior to flow stabilizing at 185 cfs for the final 73 hours of sampling. Flow recorded below the J.C. Boyle powerhouse ranged between 358 cfs and 3,000 cfs during the study. Flow in the J.C. Boyle peaking reach remained stable at approximately 520 cfs for the final 94 hours of monitoring.

TDG was measured during the maintenance event. This measurement, taken at the bridge located below the fish bypass release, resulted in a value of 103 percent and coincided with a flow of 280 cfs. An additional TDG measurement was taken at the J.C. Boyle powerhouse tailrace on July 3, 2003, following the maintenance event. Only one of the two turbines was generating at the time of the measurement. TDG was measured at 102 percent for the tailrace release of 1,750 cfs.

Iron Gate dam maintenance took place May 16-26, 2002. All water leaving the Iron Gate project during maintenance was passed through the spillway. Monitoring equipment was deployed at the USGS Iron Gate gauge, approximately ¼ mile below the dam. Data were collected about 12 hours after spilling began and continued until the project was back on line. River flows below Iron Gate dam during maintenance ranged from 1,719 to 1,490 cfs.

TDG measurements were recorded during spill mode and again at the time of unit startup. Because of high flows, the Iron Gate project continued to spill after coming back on line. Total saturation differed by 1 percent between nonspill (104 percent) and maintenance spill (103 percent) operations.

E3.5.6 Turbidity

E3.5.6.1 Applicable Oregon Water Quality Standard (OAR 340-041-0036)

No more than a 10 percent cumulative increase in natural stream turbidity may be allowed, as measured relative to a control point immediately upstream of the turbidity-causing activity. However, limited duration activities necessary to address an emergency or to accommodate essential dredging, construction, or other legitimate activities and which cause the standard to be exceeded may be authorized, provided all practicable turbidity control techniques have been applied and approval has been obtained from the relevant agency.

E3.5.6.2 Applicable California Water Quality Objective

Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

E3.5.6.3 Review of Existing Conditions with Turbidity Standard

Ambient turbidity in the Klamath River decreases throughout the length of the Project (Table E3.5-7), with the exception of the region just downstream of the mouth of Klamath Straits Drain. By trapping a portion of the sediment load carried into the reservoirs, the Project may actually reduce and mitigate the effects of high turbidity in Upper Klamath Lake and Klamath Straits Drain.

Table E3.5-7. Turbidity (NTU) data collected in the Project area in 2000 through 2003.

Reach	N	Mean	Median
Link River	36	10.7	9.1
Keno Reservoir	78	6.5	6.1
Klamath River from Keno Dam to J.C. Boyle Reservoir	16	9.9	8.4
J.C. Boyle Bypass Reach	16	4.6	3.3
Klamath River above Iron Gate Reservoir	8	4.3	3.9
Iron Gate Reservoir	18	3.4	2.9
Klamath River below Iron Gate Dam	8	3.1	2.3

Under normal operations, the Project is not a source of turbidity. However, regular or emergency maintenance on Project facilities may be a potential source of increased turbidity. Turbidity data were collected during maintenance activities at Link dam and J.C. Boyle dam.

During maintenance activity at Link dam in May 2002, turbidity was measured at two locations: 200 feet downstream from the dam in the bypass reach, and farther downstream in the peaking reach below the East Side powerhouse. Average turbidity increased at both sites during the maintenance spill, from 12.3 nephelometric turbidity units (NTUs) to 54.0 NTUs at the site below the dam, and from 10.2 to 14.9 NTUs at the site below the powerhouse. The elevated turbidity was largely confined to the bypass reach.

Turbidity was measured immediately below J.C. Boyle dam and near the downstream end of the bypass reach during maintenance activity at J. C Boyle dam in September 2002. Background data collected at both sites averaged 6.5 and 2.3 NTUs, respectively. Average turbidity values increased at both sites during maintenance, from 6.5 to 12.4 NTUs at the site near the dam and from 2.3 to 5.8 NTUs near the bottom of the bypass reach. Turbidity increased at the upper site following spill for a period of 8 hours before receding to background values. The lower site showed an increase above the average background values for 15 hours, although the actual values are lower than those recorded in the upper section of the reach for the same period. No effect on turbidity attributable to the maintenance activity was observed in the Klamath River near Shovel Creek, approximately 15 miles downstream.

One potential source of turbidity attributable to the Project is the emergency spillway for the power canal to J.C. Boyle powerhouse. When in use, discharge from the spillway can cause erosion of the canyon wall resulting in a probable increase in turbidity in the river depending on the amount of spill flow.

E3.5.7 Toxic Substances

E3.5.7.1 Applicable Oregon Water Quality Standard (OAR 340-041-0033)

(1) Toxic substances may not be introduced above natural background levels in the waters of the state in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety or welfare, aquatic life, wildlife, or other designated beneficial uses,

(2) Levels of toxic substances generally may not exceed the criteria listed in Table 20 to the rule, which are based in part on guideline criteria established by EPA in 1986.

E3.5.7.2 Applicable California Water Quality Objective

Toxicity

All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Water Board.

The survival of aquatic life in surface waters subjected to a waste discharge, or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge.

Pesticides

No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life. Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64444.5 (Table 5), and listed in Table 3-2 of the Water Quality Control Plan for the North Coast Region.

Chemical Constituents

Waters designated for use as domestic or municipal supply shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and Section 64444.5 (Table 5), and listed in Table 3-2 of the Water Quality Control Plan for the North Coast Region.

Waters designated for use as agricultural supply shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial use.

E3.5.7.3 Review of Existing Conditions with Toxic Substances Standard

ODEQ has included the Klamath River from RM 231 to RM 250 on the 303(d) list of water-quality-impaired water bodies with respect to ammonia, based on data collected from 1985 to 1996. Conditions of pH, temperature, and ammonia-nitrogen concentration during 2000 through 2002 were such that a number of sites exceeded the criterion for un-ionized ammonia provided in OAR 340-041-0033(2), Table 20. Thirty-four percent (178 of 519) of ammonia samples from throughout the Project area in 2000 through 2002 exceeded the acute toxicity criterion. The majority of those samples (64) were from Keno reservoir and from the hypolimnion of J.C. Boyle reservoir (19), Copco reservoir (22), and Iron Gate reservoir (13).

Studies are currently under way to determine if toxic pollutants are present in the Project reservoirs in amounts that would present concerns for fish consumption. Fish tissue samples were collected from all Project reservoirs in 2003 through a cooperative agreement between PacifiCorp and the California Department of Fish and Game. Tissue sample analysis is currently under way. Results will be reported as soon as they are available (see the Water Resources FTR, Section 10.0).

E3.5.8 <u>Biocriteria</u>

E3.5.8.1 Applicable Oregon Water Quality Standard (OAR 340-041-0011)

Oregon has adopted the following narrative "biocriteria" standard: "Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities." The criterion is intended to be the basis for future watershed-specific numeric biocriteria and is not intended to establish a standard that is more stringent than other existing narrative water quality criteria and requirements to provide sufficient water quality to protect designated aquatic uses.

E3.5.8.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for biocriteria.

E3.5.8.3 Review of Existing Conditions with Biocriteria Standard

The waters of the Project area support a wide variety of fish and other aquatic species that are self-sustaining, as well as providing recreational harvest opportunities. The Klamath River between Keno dam and J.C. Boyle reservoir, and from J.C. Boyle dam to Copco reservoir is managed for wild trout. J.C. Boyle, Copco, and Iron Gate reservoirs support popular recreational largemouth bass fisheries. Native trout, coho salmon, Chinook salmon, steelhead trout, and Pacific lamprey inhabit and spawn in the Klamath River below the Project area. Details on the condition of fish and other aquatic species in the Project area are provided in the Fish Resources FTR and Section E4 of this Exhibit E.

E3.5.9 Aesthetic Conditions

E3.5.9.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(15))

Aesthetic conditions offensive to the human senses of sight, taste, smell, or touch may not be allowed.

E3.5.9.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for aesthetic conditions.

E3.5.9.3 Review of Existing Conditions with Aesthetic Conditions Standard

PacifiCorp conducted a survey of recreational users in the Project area in 2001 (see Recreation Resources FTR). The survey did not ask questions directly relevant to Oregon water quality criteria or California water quality objectives; however, some respondents offered comments concerning water quality. Twenty-six percent of respondents in a survey of recreational users in the Project area said that water quality had detracted from their visit. Their responses are summarized in Table E3.5-8.

Table E3.5-8. Summary of survey responses citing netagive reaction to water quality in the Project area, 2001. Percents of cited factors sum to greater than all respondents because of multiple responses.

Area	All Respondents (%)	Cited Factor (%)				
		Algae	Smell	Dirty	Flow [1]	Other [2]
Lake Ewauna/Keno Reservoir	7.4	3.0	1.5	1.5	0	2.6
J.C. Boyle Reservoir	5.9	3.0	0	3.0	0.3	0.7
Upper Klamath River/Hell's Corner Reach	7.1	1.5	0	1.8	1.5	1.8
Copco Reservoir	2.9	0.7	0	1.1	0	1.5
Iron Gate Reservoir	21	10	1.1	1.8	2.6	6.7
Other [3]	26	8.5	0.7	3.3	4.1	10
Total	**26**	**10**	**1.1**	**4.1**	**3.7**	**8.9**

[1] The use of the term "flow" here includes both flow amount and changes in river or reservoir water levels.
[2] In these instances, comments did not provide a specific factor, were too general, or could not be clearly interpreted.
[3] In these instances, comments did not indicate a specific area, or indicated that the response applied to "all" or "everywhere." Two of the listed comments indicated "below Iron Gate" and four indicated "Upper Klamath Lake."

Of those persons who felt that water quality detracted from their visit, the most commonly cited factor was algae or aquatic plants ("algae, green stuff, muck, seaweed, moss, slime") and the attendant odor. Other factors that were mentioned included dead fish and turbidity as a result of powerboat operations.

As indicated above, however, these factors are not the result of the Project itself, but rather are an indirect effect of the excessive nutrient contribution to the Project from agriculture and other sources. Moreover, Project reservoirs and other facilities are the principal recreational attraction.

E3.5.10 <u>Bacteria</u>

E3.5.10.1 Applicable Oregon Water Quality Standard (OAR 340-041-0009)

Freshwater. Organisms of the coliform group commonly associated with fecal sources may not exceed the following criteria:

- A 30-day log mean of 126 E. coli organisms per 100 milliliters (ml), based on a minimum of five samples
- A single sample over 406 E. coli organisms per 100 ml

Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or otherwise injurious to public health may not be allowed.

E3.5.10.2 Applicable California Water Quality Objective

The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels. In no case shall coliform concentrations in waters of the North Coast Region exceed the following:

In waters designated for contact recreation (REC-1), the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml (State Department of Health Services).

E3.5.10.3 Review of Existing Conditions with Bacteria Standard

No data that relate to this standard have been collected or are known to PacifiCorp. However, there is no reason to suspect that the Project affects bacteria, because there is no significant Project-related discharge of raw or treated sewage or animal waste into Project waters. Domestic wastes at the dams and worker housing are treated in on-site septic systems.

E3.5.11 <u>Fungi or Other Growths</u>

E3.5.11.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(11))

“The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or that are injurious to health, recreation, or industry may not be allowed.”

E3.5.11.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for fungi.

E3.5.11.3 Review of Existing Conditions with Fungi or Other Growths Standard

No nutrients are added to the water as a result of Project facilities or operations that will support the proliferation of fungi. Project facilities do not, in conjunction with nutrients from other sources, cause deleterious effects on beneficial uses.

E3.5.12 Tastes or Odors

E3.5.12.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(12))

"The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed."

E3.5.12.2 Applicable California Water Quality Objective

Waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.

Numeric water quality objectives with regards to taste and odor thresholds have been developed by the State Department of Health Services and USEPA. These numeric objectives, as well as those available in the technical literature, are incorporated into waste discharge requirements and cleanup and abatement orders as appropriate.

E3.5.12.3 Review of Existing Conditions with Tastes or Odors Standard

There are no data to suggest and no reason to believe that the Project or any constituent of the waters within the Project imparts an undesirable taste or odor to fish or other edible products.

E3.5.13 Sludge Deposits

E3.5.13.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(13))

"The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed."

E3.5.13.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for sludge or bottom deposits. There are, however, several related provisions dealing with sediment.

Suspended Material

Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

Settleable Material

Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.

Sediment

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

E3.5.13.3 Review of Existing Conditions with Sludge Deposits Standard

The Project adds no nutrients, organic matter, or inorganic matter to the water that would result in the production of bottom sludge or deposits or objectionable suspended matter. Operation of the project may result in changes in water volume and velocity that may alter the suspended sediment load and suspended sediment discharge rate in portions of the project, but this does not create a nuisance or adversely affect designated uses.

E3.5.14 Objectionable Discoloration, Oily Sheens, or Floating Solids

E3.5.14.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(14))

"Objectionable discoloration, scum, oily sheens, or floating solids, or coating of aquatic life with oil films may not be allowed."

E3.5.14.2 Applicable California Water Quality Objective

Color

Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.

Oil and Grease

Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

Floating Material

Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.

E3.5.14.3 Review of Existing Conditions with Standard

Nothing is added to the water by the Project to cause objectionable discoloration, scum, oily sheens, floating solids, visible films, or coating of objects or aquatic life. PacifiCorp maintains spill prevention and control plans to avoid and minimize accidental spill or discharge of material that may cause discoloration, scum, or oily sheens.

Abundant foam is frequently seen on the Klamath River, especially below stretches of rapidly flowing water. This has been noted since the time of early settlement in the basin, and is a natural consequence of the agitation of the water and the abundant organic matter in the river.

E3.5.15 Radioisotopes

E3.5.15.1 Applicable Oregon Water Quality Standard (OAR 340-041-0007(16))

"Radioisotope concentrations may not exceed maximum permissible concentrations (MPC's) in drinking water, edible fishes or shellfishes, wildlife, irrigated crops, livestock and dairy products, or pose an external radiation hazard."

E3.5.15.2 Applicable California Water Quality Objective

Radionuclides shall not be present in concentrations which are deleterious to human, plant, animal or aquatic life or which result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or indigenous aquatic life.

Waters designated for use as domestic or municipal supply shall not contain concentrations of radionuclides in excess of the limits specified in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64443, Table 4, and listed in Table E5.5-9.

Table E3.5-9. Maximum Contaminant Level – Radioactivity.

Constituent	Level, pCi/L
Combined Radium-226 and Radium-228	5
Gross Alpha Particle Activity (including Radium-226 but excluding radon and uranium)	15
Tritium	20,000
Strontium-90	8
Gross Beta Particle Activity	50
Uranium	20

pCi/L = picoCurie per liter.

E3.5.15.3 Review of Existing Conditions with Radioisotopes Standard

No radioisotopes are being added to the water by the Project facilities or operations, and there are no known naturally occurring problems with radioisotopes.

E3.5.16 Total Dissolved Solids

E3.5.16.1 Applicable Oregon Guideline Water Quality Standard (OAR 340-041-0185(2))

"The specific conductance may not exceed 400 micro-mhos at 77°F when measured at the Oregon-California Border (river mile 208.5)...unless otherwise specifically authorized by DEQ upon such conditions as it may deem necessary to carry out the general intent of this [water quality management] plan and to protect the beneficial uses" designated for the Klamath River basin.

E3.5.16.2 Applicable California Water Quality Objective

The Water Quality Control Plan for the North Coast Region does not include a specific water quality objective for total dissolved solids.

E3.5.16.3 Review of Existing Conditions with Total Dissolved Solids Standard

Of 150 measurements for specific conductance (a total dissolved solids surrogate) taken in 2000 through 2003 in the Klamath River between Link dam and the Shasta River, the mean was 116 µS/cm (equivalent to micromhos/cm), the median was 123 µS/cm, and no sample exceeded 273 µS/cm. For 5,942 measurements of specific conductance recorded on the Klamath River from Link Dam to the mouth between 1951 and 2001, the mean was 179 µS/cm, the median was 173 µS/cm, and only 0.8 percent of measurements were greater than 400 µS/cm.

E3.5.17 Antidegradation

E3.5.17.1 Applicable Oregon Water Quality Standard (OAR 340-041-0004)

Where the existing water quality meets or exceeds those levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, and other designated beneficial uses, that level of water quality must be maintained and protected. However, the Environmental Quality Commission may allow a lowering of water quality in these high quality waters if certain conditions are met.

Water-quality-limited waters may not be further degraded except under certain limited circumstances.

E3.5.17.2 Applicable California Antidegradation Policy

Whenever the existing quality of water is better than the water quality objectives established herein, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California."

E3.5.17.3 Review of Existing Conditions with Antidegradation Standard

PacifiCorp is proposing no action that would result in lowering of water quality in Project waters.

E3.6 CONSULTATION WITH AGENCIES, TRIBES, AND THE PUBLIC ON WATER USE AND QUALITY

PacifiCorp began its relicensing consultation effort for the Klamath Hydroelectric Project using the basic approach established by the Traditional Licensing Process. The process was initiated in December 2000 by the distribution of the Notice of Intent to FERC and the First Stage Consultation Document in which PacifiCorp provided an overview of the Project and resources in the Project area and proposed certain studies needed to support development of the license application. The formal comments of stakeholders to the First Stage Consultation Document produced over 175 letters and conveyed broad-ranging concerns with the adequacy of the study plans, PacifiCorp's decision not to study dam decommissioning, and the level of collaboration in developing study plans.

In response to these comments, PacifiCorp revised its proposed study plans and redistributed them in the form of a draft Second Stage Consultation Document. Stakeholder response was again vigorous and reiterated the concerns expressed in the first round of comments. In response to these strong stakeholder interests and concerns, the relicensing process evolved into a collaborative effort with over 40 stakeholders engaged in a long-term effort to develop and approve study plans, review and interpret results and potentially agree on protection, mitigation, and enhancement (PM&E) measures. Details of the consultation effort to date are provided in the document titled PacifiCorp Consultation Record for Relicensing the Klamath Hydroelectric Project (Appendix E-1A).

Beginning in February 2001, stakeholders developed a Process Protocol to guide the long-term collaborative effort and a collaborative structure composed of a plenary group (all interested stakeholders) and seven technical working groups that convene each month for facilitated meetings. One of the technical working groups is the Water Quality Work Group. The focus of the water quality meetings was to develop and approve final water quality study plans. Recognizing time constraints for completing relicensing studies, the collaborative group endorsed the need to implement elements of those studies not yet approved. Stakeholders also worked simultaneously to approve study plan portions that were critical for initiating fieldwork and modeling work, while also reviewing and finalizing study plans.

The plenary group serves as the managing body of the Collaborative Process and is composed of all participants in the Collaborative Process. The assignment and approval of all Water Quality Work Group and Aquatic Work Group study plans and all related final consensus decisions are the responsibility of the plenary group. Two of the work groups—the Water Quality Work Group and the Aquatics Work Group—are tasked with addressing issues and studies related to water use and quality as presented in this section of Exhibit E. The Water Quality Work Group has been assessing existing water quality data, water temperature and water quality conditions, hydrologic and water quality modeling efforts, water quality during Project maintenance operations, macroinvertebrates, sediment oxygen demand in Project reservoirs, contamination of sediment in Lake Ewauna and Keno reservoir, and freshwater bivalves. The Water Quality Work Group met 22 times between September 2001 and December 2003.

The Aquatics Work Group is tasked with addressing instream flow issues and describing impacts to aquatic resources, including habitat, connectivity, and species interaction. Studies include analysis of Project effects on sediment transport and river geomorphology, evaluation of ramping, fisheries assessment, instream flow scoping and analysis, investigation of trout movement, effects of flow fluctuation on aquatic resources, investigation of trout and anadromous fish genetics, and investigation of the fish disease *Ceratomyxa shasta* in the Klamath River (see Section E4 (Fish Resources) of this Exhibit E. The Aquatics Work Group has met 22 times since September 2001.

Twelve study plans related to hydrology, geomorphology, and water quality were developed by these two work groups for the purpose of improving their knowledge of the existing water quality or the potential effects of the Project on water quality. All 12 of the study plans were approved by the plenary group. The study plans (and their approval dates) are as follows:

- Study Plan 1.1, Compilation and Assessment of Existing Water Quality Data (Approval: August 2002)
- Study Plan 1.2, Monitoring of Water Temperature and Water Quality Conditions in the Project Area (Approval: October 2002)
- Study Plan 1.3, Water Quality Analysis and Modeling Process (Approval: October 2002)
- Study Plan 1.4, Analysis of Project Effects on Hydrology (Approval: November 2002)
- Study Plan 1.5, Analysis of Project Effects on Sediment Transport and River Geomorphology (March 2003)
- Study Plan 1.6, Monitoring and Analysis of Water Quality during Project Maintenance Operations (Approval: August 2002)
- Study Plan 1.11, Fall 2002 Macroinvertebrate Study (Approval: February 2003)
- Study Plan 1.13, Determination of Sediment Oxygen Demand in Selected Project Reservoirs (Approval: December 2002)
- Study Plan 1.14, Screening Level Determination of Chemical Contaminants in Fish Tissue in Selected Project Reservoirs (Approval: March 2003)
- Study Plan 1.19, Investigation of Klamath River Freshwater Bivalves in the J.C. Boyle Peaking Reach and Downstream of Iron Gate Dam (Approval: April 2003)
- Study Plan 1.20, Spring 2003 Macroinvertebrates Study (Approval: April 2003)
- Study Plan 1.22, Analysis of Potential Project Effects on Water Quality Aesthetics (Approval: December 2003)

E3.7 WATER QUALITY STUDIES

The following sections summarize the purpose, methods, and results of the 12 water quality studies listed above. More detailed reports for these studies are contained in respective sections of the Water Resources FTR.

E3.7.1 Compilation and Assessment of Existing Water Quality Data (Study 1.1)

E3.7.1.1 Purpose

An extensive body of existing water quality data and information already exists for the Klamath Project area, but it comes from multiple sources and is presented in differing forms. PacifiCorp collected the available data and assembled them in an electronic database. The database provides a basis against which to compare current water quality, identify spatial and temporal trends in water quality, identify key data gaps, and provide guidance for developing additional studies.

E3.7.1.2 Methods

PacifiCorp compiled relevant water quality data and information for the Project into a computerized database. Data were evaluated for quality and completeness. Plots and statistical analyses were performed to assess historical trends, both temporal and spatial. The analysis of data compiled in the database consisted primarily of nonparametric exploration of data trends, distributions, and site comparisons. The analysis produced summary graphs, plots, and tables of these trends, distributions, and site comparisons. Details on methods for this study are contained in the Water Resources FTR.

E3.7.1.3 Results

The water quality database is available on PacifiCorp's relicensing website at http://newwww.pacificorp.com/Article/Article579.html. The website link to the database opens a self-extracting zip file containing the database and accompanying information file. Microsoft Access 2000® is required to open the database. Observations and interpretations from this study are contained in the Water Resources FTR. Results are summarized in section E3.2.

E3.7.2 Monitoring of Water Temperature and Water Quality Conditions in the Project Area (Study 1.2)

E3.7.2.1 Purpose

The purpose of this study was to obtain data to characterize current water quality conditions (since 2000) within and downstream of the Project area. The data from this study were used to support modeling and assessment of the Project's potential effects on water quality (as described in the Water Resources FTR, Section 4.0 (Development of Water Quality Analysis and Modeling Framework). Important questions related to Project operations were (1) whether and how these operations might contribute to water quality conditions, and (2) whether and how Project operations might feasibly contribute to water quality improvements.

E3.7.2.2 Methods

PacifiCorp cooperated with USBR in a water quality monitoring program to characterize water quality conditions in the Klamath River from Link River (RM 254.8) to the Shasta River (RM 176). Thirty-three sites on the Klamath River between Upper Klamath Lake and the mouth of the Shasta River were sampled for water quality constituents in 2000 through 2003 (see Figure E3.3-1 for sampling site locations; see Table E3.3-1 for the number of samples collected by site and by year). Sampling sites were chosen to provide information suitable for calibration and validation of water quality models being developed by PacifiCorp as part of the Project relicensing process. Details on methods for this study are contained in the Water Resources FTR and summarized in section E3.3.

E3.7.2.3 Results

Observations and interpretations from this study are described in the Water Resources FTR, Section 3.0, and are summarized in section E3.3.

E3.7.3 Water Quality Analysis and Modeling Process (Study 1.3)

E3.7.3.1 Purpose

The purpose of this study was to implement analysis and modeling tools to help assess water quality compliance in the Project area and determine how the Project contributes to or controls water quality conditions in and downstream of the Project area. The analysis and modeling tools are used to support subsequent assessment of possible water quality PME measures where necessary. Important questions related to Project operations are (1) whether and how these operations might contribute to water quality conditions, and (2) whether and how Project operations might feasibly contribute to water quality improvements.

E3.7.3.2 Methods

A flow and water quality modeling framework for the Klamath River from Link Dam (RM 255) to Turwar (RM 6) was designed and implemented to support studies for the Project relicensing process. The framework and detailed supporting documentation are provided in the Water Resources FTR, Appendix 4A. Three specific tasks are outlined as follows.

1. Model implementation
2. Calibration and validation
3. Model application

Model implementation is the process of gathering the appropriate data (geometry, flow, water quality, meteorology) and formatting it for input into the selected models. This step includes selection of default model parameters and general model testing. The end result is a running, but uncalibrated model. At the next stage, model calibration and validation model parameters are modified to fit the model to field observations—calibration. The model is then tested on an independent set of data—validation—to confirm that the model can replicate field conditions for the parameter values determined in calibration. The final stage is model application, wherein the calibrated models are applied to selected management strategies or scenarios. Such scenarios may vary flow or water quality conditions, or they may include the addition or removal of Project facilities to identify potential impacts and outcomes.

The Klamath River between Link dam (near Klamath Falls, Oregon) and Turwar, California, is roughly 250 river miles. Throughout this reach the river undergoes a wide range of natural and anthropogenic influences. It is impounded by five dams: Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate. There are diversions and return flows for agriculture, predominantly in the reach between Link dam and Keno dam, and for hydropower at Link dam and J.C. Boyle dam. The river receives inflow from several tributaries and springs as well.

To address these diverse characteristics, separate river models and reservoir models were selected. The river models consist of a suite of models produced by RMA. The flow component is represented with RMA-2, a finite element hydrodynamic model capable of modeling highly dynamic flow regimes at short space and time steps. The outputs from this model—velocity, depth, and representative surface and bed areas—are passed to the water quality model RMA-11. RMA-11 is a full water quality finite element model, simulating the fate and transport of a wide range of physical, chemical, and biological constituents based on information produced by RMA-2. The suite of river models is applied on a sub-daily time step to capture the short-term response of parameters, such as temperature and dissolved oxygen. The RMA models are applied in one dimension for the river reaches. For this application, the variations along the longitudinal axis of the stream are represented, with the vertical and lateral directions averaged.

The two-dimensional longitudinal/vertical hydrodynamic and water quality model CE-QUAL-W2 was applied to system reservoirs (Copco No. 2 is a small reservoir and was not modeled within the framework). Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow water bodies exhibiting longitudinal and vertical water quality gradients, but it can be applied to a wide range of physical configurations. The model is capable of representing a wide range of water quality processes, including physical, chemical, and biological (benthic algae and phytoplankton) processes. The model can simulate selective withdrawal, sediment nutrient release dynamics, nitrogen inhibition under anoxic conditions, internal weirs and curtains, and other useful options to assess a wide range of existing and current conditions.

The river and reservoir models were implemented for discrete river reaches. The nine reaches are listed in Table E3.7-1 and shown in Figure E3.7-1. The model implementation process includes constructing appropriate system geometry, flow and water quality conditions (boundary conditions, initial conditions, calibration/validation data), meteorological data and other model parameters.

- Geometry data include a description of the river location, i.e., latitude and longitude or similar coordinate system, bed slope, and cross-section data, bathymetric information, and facilities information (stage-volume data; intake structure capacities, sizes, elevations; locations of diversions structures and return points).

- Flow and water quality information include system inflow (e.g., mainstem points, tributaries, return flows), outflow (diversions), storage change, and operations. Water quality data for all inflows as well as in-river and reservoir conditions are required.

- Meteorological data include standard parameters for heat budget calculation within the numerical models, e.g., air temperature, wet bulb temperature, dew point temperature, solar radiation, cloud cover, wind speed, and/or barometric pressure.

- Other model parameters such as time step, spatial resolution, periods of analysis, selection of default model constants and coefficients.

Table E3.7-1. River reaches and representation in the modeling framework.

Reach	Existing Representation	Model(s)
Link River	River	RMA-2/RMA-11
Lake Ewauna Keno Dam	Reservoir	CE-QUAL-W2
Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11
J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2
J.C. Boyle Bypass Reach[1]	River	RMA-2/RMA-11
J.C. Boyle Peaking Reach[1]	River	RMA-2/RMA-11
Copco Reservoir[2]	Reservoir	CE-QUAL-W2
Iron Gate Reservoir	Reservoir	CE-QUAL-W2
Iron Gate Dam to Turwar	River	RMA-2/RMA-11

[1] The bypass and peaking reaches are modeled as a single reach.

[2] The small Copco No. 2 reservoir is not represented in the framework.

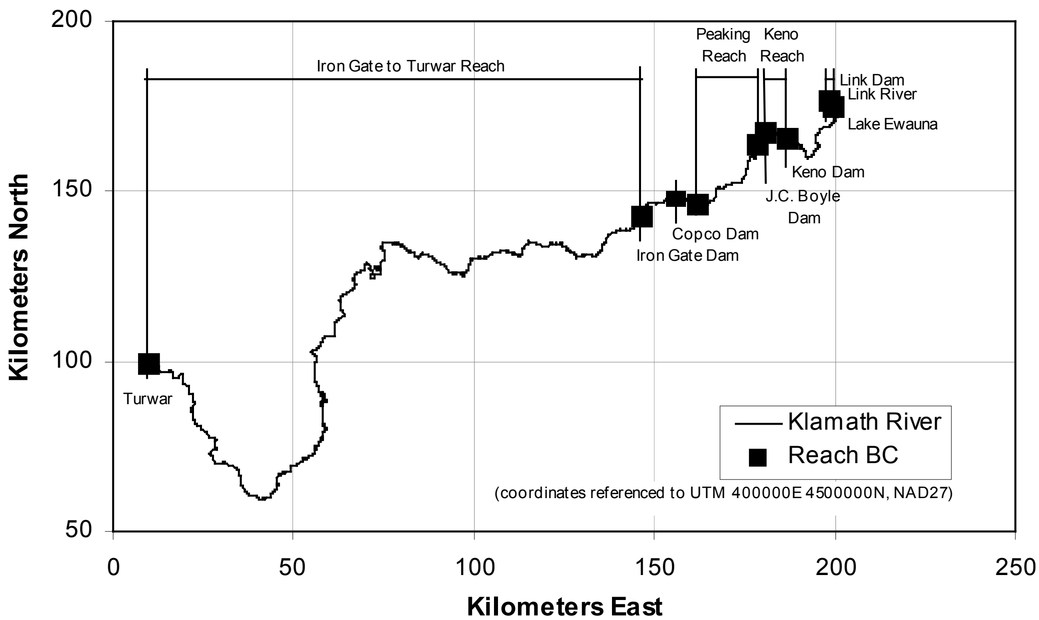


Figure E3.7-1. Designated river reaches and reservoirs.

The application of the river and reservoir models collectively provides the ability to simulate flow and water quality conditions from Link dam (RM 255) to the Klamath River near Turwar (RM 6). The objective of the modeling framework was to enable the assessment of individual reaches or a set of reaches, or to simulate conditions throughout the system. For systemwide simulation, the models were run in sequence, starting at Link River reach and progressing downstream. Output from the upstream model was used as the upstream condition for the subsequent downstream model.

Model Scenarios

The Klamath River modeling framework was used to analyze four scenarios applied to the entire modeling network: existing conditions, steady flow, without-Project, and without-Project II. In each case, river and/or reservoir reaches were simulated in sequence from upstream to downstream, with output from one modeled reach providing input for the immediate downstream reach. In addition, the model was used to assess potential water quality enhancement measures at specific Project locations, including selective withdrawal for water temperature management at Iron Gate reservoir, hypolimnetic oxygenation at Iron Gate reservoir, and instream flow release effects in the J.C. Boyle bypass reach.

Flow conditions and facilities (reservoirs) defined the primary variations among the four scenarios and are outlined in detail below. All flow boundary conditions (e.g., Link dam, USBR operations, diversion and return flows, tributary inflows) were consistent throughout the four scenarios unless noted. Likewise, water quality boundary conditions remained the same for each scenario. These boundary conditions representing tributaries, return flows, and accretion/depletions include temperature and water quality constituents (dissolved oxygen, organic and inorganic nutrients, BOD/organic matter, and algae concentrations). Where available, temperature and water quality boundary conditions were derived from field observations; in certain cases, however, no observations were available and temperature and water quality conditions were estimated. Meteorological observations at Klamath Falls were used within each subreach. Air temperature was corrected for changes in elevation in middle and lower Klamath River reaches.

Existing Conditions

The existing conditions (EC) scenario represents current facilities, operations, and general water quality conditions throughout the river system. This scenario combined the existing geometry of the river reaches and reservoirs with the observed river flows, diversions, tributary contributions, and dam releases/operations for calendar year 2000. System operations include peaking releases from J.C. Boyle and Copco dams.

Steady Flow

The steady flow (SF) scenario represents conditions without peaking hydropower operations at J.C. Boyle and Copco reservoirs. To determine flow conditions for the SF scenario, river flows and reservoir releases were calculated via water balance starting at Iron Gate dam and progressing upstream. Reservoir storage was presumed to remain constant, to the degree possible (e.g., spilling), throughout the year—i.e., reservoir inflow equaled reservoir outflow. The same geometry, flow and water quality boundary conditions, and meteorological data as the EC scenario were employed.

Without Project

The without-Project I (WOP) scenario represents conditions with no reservoirs in place. The river model was extended through each reservoir reach. In the Lake Ewauna-Keno dam reach, the channel widths were reduced to represent riverine versus impounded conditions and the bedrock sill near Keno was included in the geometry. At J.C. Boyle, Copco, and Iron Gate reservoirs, the river location was based on bathymetric surveys, and river width was assumed constant based on river geometry at locations above and below existing reservoirs. Those river reaches that replaced reservoirs were presumed approximately equivalent in length to existing reservoirs, except Copco reservoir, wherein the WOP river reach length was roughly 1.2 miles longer than the existing reservoir. The same flow and water quality boundary conditions and meteorological data as the EC scenario were employed.

Without-Project II

All conditions in the without-Project II (WOP II) scenario are the same as those for the WOP scenario with the exception of the hydrology. The primary purpose of this scenario was to smooth out the flow variability (evident in the WOP scenario) being routed down the river during summer periods. These variations, which are most prominent between Julian day 200 and 250, originate with USBR project operations and maintenance of Keno reservoir at a stable water surface elevation during operations. The fluctuation resulting from USBR project operations can, over the span of a few days, exceed 500 cfs. The original WOP scenario assumed that all USBR operations were consistent with historical conditions, in which case the flow variations that were historically "re-regulated" by system reservoirs were routed down the river. Stakeholder input identified this as an unrealistic without-Project operation and requested that attempts be made to smooth the hydrograph that was routed down the river.

Other Scenarios

Stakeholders have indicated or suggested that PacifiCorp should examine other types of scenarios. In fact, PacifiCorp is in the process of conducting two additional specific scenarios for use by the plenary group in completing a Systems Landscape Options Matrix (SLOM). These include a SLOM scenario that assumes Copco and Iron Gate Developments are removed, and a SLOM scenario that assumes Iron Gate is removed. Results of these two additional SLOM scenarios should be available for review in early spring 2004.

E3.7.3.3 Modeling Results

Model simulations were performed for the four scenarios for various Klamath River sites between Link dam (RM 255) and Turwar (RM 6). Some of the results are discussed earlier in sections E3.3 and E3.5. A detailed presentation of results is provided in the Water Resources FTR, Section 4.0.

E3.7.4 Analysis of Project Effects on Hydrology (Study 1.4)

E3.7.4.1 Purpose

The purpose of this study was to determine how much control and what effects the Project hydroelectric facilities (reservoirs) and operations have on the hydrology of the Klamath River. This study provided a detailed explanation and understanding of flow regulation into, within, and downstream of the Project area. The study assessed the potential effects of PacifiCorp operations and activities on the hydrologic regime, including the magnitude, duration, and timing of monthly discharges, annual high flows, and daily and hourly fluctuations in river flows and reservoir water levels.

E3.7.4.2 Methods

Explanation of Facilities and Operational Issues Associated with the Project

A PacifiCorp report issued in May 2002 provides a detailed explanation of flow regulation and operation into, within, and downstream of the Project area. In particular, the report describes the relative roles and responsibilities of USBR and PacifiCorp for lake, reservoir, and river flow operations, and how these operations are coordinated. Specific details are provided on the operations at each facility and on relevant agreements and obligations. This report formed the basis for the discussion of flow regulation and operation in Section 5.0 of the Water Resources FTR, Exhibit B, and section E3.1.

Effects on the Annual Hydrologic Regime

This study included analysis of the effects on flows in the Project area resulting from historical and proposed operations of USBR's Klamath Irrigation Project. USBR's KPOPSIM model was used as the analytical tool to evaluate semimonthly, monthly, seasonal, and annual impacts on Klamath River flows. This analysis also accounted for the effects of PacifiCorp facilities operations relative to effects from USBR's Klamath Irrigation Project operations.

The KPOPSIM model incorporates the USBR Klamath Irrigation Project (Upper Klamath Lake, Gerber Reservoir, and Clear Lake) and the PacifiCorp Hydroelectric Project (Klamath River operations between Link River dam and Iron Gate dam). See the KPOPSIM model documentation[20] for a complete description of model setup, assumptions, and spatial representation of the modeled area. Gerber Reservoir and Clear Lake have very little, if any impact on the Klamath River; therefore, they were not included in the KPOPSIM simulation. PacifiCorp facilities on the Klamath River include J.C. Boyle, Copco, and Iron Gate reservoirs.

Analysis of Existing Hydrologic Data

This study included analysis of daily and hourly hydrologic data from USGS gauging stations and Project facilities. Daily data that were examined included the entire period of record; hourly data that were examined included several recent years of hourly data for the period from about 1990 to present (including hourly data on river flow, reservoir elevation, flow through turbines, and spill). This analysis was used to depict the various modes of Project operations and to relate these operations to specific effects on short-term (daily and hourly) changes in river flow and reservoir water levels.

Flow and Hydrodynamics Modeling

The water quality modeling framework developed for Project water quality analysis included hydrodynamics flow-routing models. For riverine reaches, the hydrodynamic model RMA-2 was used.[21] RMA-2 is specifically designed to assess flow response in complex river systems. For

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[20] *U.S. Bureau of Reclamation Home Page.* August 10, 1998. http://www.mp.usbr.gov/kbao/models/index.html. Accessed: February 25, 2003.

[21] RMA-2 was used in combination with RMA-11 to provide a complete and comprehensive water quality model. RMA-11 uses the geometry and output of RMA-2, and solves the advection-diffusion equation to determine the fate and transport of up to 16 water quality constituents.

Project reservoirs, the model CE-QUAL-W2 was used.[22] This model effectively simulates the routing of flow through reservoir geometry and predicts reservoir water surface elevations. These models were used to examine the short-term hydrology and hydrodynamics effects of Project operations scenarios, together with examination of water quality effects.

E3.7.4.3 Results

Average Daily Flow Rates

Graphs of average daily flow by month at the four key USGS gauges are provided in the Water Resources FTR, Appendix 3A. Figure E3.1-1 depicts annual hydrographs of average daily flow over the period 1967-2001 for the four key USGS gauges. To illustrate flow variation in recent years, Figure E3.1-2 shows the annual hydrographs of average daily flow at the Keno gauge (No. 11509500), together with annual hydrographs for 1991 (a critical dry year) and 1998 (a wet year).

Figure E3.1-3 shows the 50 percent (median) monthly flow values for Fall Creek for three scenarios. These are: (1) period of record only, representing historic Fall Creek conditions without an additional diversion from Spring Creek; (2) 5 cfs diverted, representing the minimum expected Spring Creek diversion flow plus historical conditions; and (3) 16.5 cfs Spring Creek diverted, the sum of historical conditions and the maximum allowed diversion.[23]

Daily Flow Duration Curves by Month

Daily flow duration curves, by month, at the four key USGS gauges are provided in Appendix 5A in the Water Resources FTR. These curves indicate the percent of days for a particular month that a given flow has been equaled or exceeded. Appendix 5B of the Water Resources FTR provides the 90 percent, 50 percent, and 10 percent exceedance values for Fall Creek flow, corresponding to wet, average, and dry conditions, reported for the three scenarios described above.

Current Flow Management in the Project Area

The May 2002 PacifiCorp report provides a detailed explanation of flow regulation and operation into, within, and downstream of the Project area. In particular, the report describes the relative roles and responsibilities of USBR and PacifiCorp for lake, reservoir, and river flow operations, and how these operations are coordinated. Specific details are provided on the operations at each facility and relevant agreements and obligations. This document can be accessed at http://newwww.pacificorp.com/File/File17804.pdf. The document formed the basis for the discussion on flow regulation and operation in Section 5.0 of the Water Resources FTR, Exhibit B, and section E3.1.

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22 Different models were selected for riverine reaches and reservoirs because of fundamental differences in their geometric, hydraulic, and water quality characteristics. See Study Plan 1.3 for further discussion on model purpose and selection.

23 Although it is likely that the range of Spring Creek diversions (5 to 16.5 cfs) follows a seasonal pattern, with higher flows in later winter and spring and low flows in late summer and autumn, no data were available to confirm this. For that reason, the range of diversions and water year types were overlain to provide a range of flow values and associated exceedances, regardless of time of year.

Effects of PacifiCorp Operation on the Annual Hydrologic Regime

As described earlier, the effects of the Project on the long-term (monthly, seasonal, and annual) hydrologic regime was examined using KPOPSIM model simulations. KPOPSIM was used to assess the impacts of historical operations on Klamath River flows below Iron Gate dam resulting from both USBR's project and PacifiCorp's operations of J.C. Boyle, Copco, and Iron Gate reservoirs. KPOPSIM simulations and results are presented in the Water Resources FTR, Section 4.0.

The analysis of effects of the PacifiCorp Project on daily and hourly flows is discussed in section E3.3. Detailed discussion of results is provided in the Water Resources FTR, Section 4.0.

E3.7.5 Analysis of Project Effects on Sediment Transport and River Geomorphology Study 1.5)

E3.7.5.1 Purpose

The purpose of this study was to characterize sediment transport and geomorphic conditions and controlling factors in the Project area, including understanding the potential effects of Project operations. As one component of this study, PacifiCorp assessed fluvial geomorphic processes and conditions in various river reaches by evaluating the range and trends of bed material size and channel form, estimating flows required to mobilize the riverbed material, and identifying bed armoring and channel change. As another component of this study, PacifiCorp assessed the character and quantity of sediments being retained in Project reservoirs. From this information, PacifiCorp identified distinct geomorphic reaches, determined the important factors that control geomorphic processes and conditions in these reaches, assessed potential sediment sources and transport through these reaches, and described potential Project effects on geomorphic processes and conditions.

E3.7.5.2 Methods

PacifiCorp collected bathymetric data in Keno,[24] J.C. Boyle, Copco, and Iron Gate reservoirs in fall 2001 using SONAR/DGPS equipment with a positional accuracy of approximately 6 cm. The positional accuracy was verified against available registered benchmarks for the area. The acoustic data were generated at a frequency of every second along transects from 50 to 100 m, depending on the size of the domain being mapped. Sediment cores were collected in specific locations of each reservoir to determine the size distribution of materials transported to the reservoir. For each reservoir, impoundment bathymetry maps were produced and hypsographic curves of the Project reservoirs were calculated (for information on lake surface area, maximum depth, mean depth, and volume).

Existing information on hydrology, geology, and geomorphology in and downstream of the Project area was reviewed to provide background and context for geomorphic characterization. Available historical photography was compiled and examined (to include vertical and oblique aerial photographs, and historical ground photographs) to document former channel conditions. Existing topographic maps and recent aerial photographs were used to develop estimates of channel gradient and confinement. Initial reach segmentation was based on distinct changes in channel slope, channel width and confinement, and other major channel features.

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[24] For Keno reservoir, only the lower portion of the reservoir (approximately 1,600 m) was mapped in standard resolution.

Fourteen representative reaches were selected in the Klamath River from Link River dam (RM 253.7) downstream to Seiad Valley (RM 128.5) in which to conduct field observations and measurements. These reaches are distributed relative to Project areas as follows: one in Link River (RM 253.1-254.3), one in the Keno reach (RM 228-233), two in the J.C. Boyle bypass and four in the J.C. Boyle peaking reaches (RM 204-224.7), one in the bypass reach below Copco No. 2 dam (RM 196.8-198.3), and five from Iron Gate dam downstream to Seiad Valley (RM 128.5-190). Each representative reach is approximately ten channel widths in length, selected in part to capture examples of channel and habitat features (e.g., pools, riffles, rapids, and bars) and to capture both highly constrained and wider alluvial reaches. Measurements and observations at representative reaches were conducted mostly during August 2002.

In each representative reach, two to four cross sections were surveyed to adequately capture variety in channel form. A long profile was surveyed over the length of the representative reach, at least ten channel widths in length. Within each representative reach, the distribution of units of distinct bed material composition (facies) were mapped, and pebble counts (Wolman, 1954) were conducted on all major facies. Floodplain and terrace attributes were noted—such as elevation, grain size, stratigraphy if visible in cut banks, and distribution of woody riparian vegetation with respect to the channel—and distance above and away from the channel. This sampling was coordinated with the wetland and riparian plant community characterization (Study 2.2) so that investigators could be on site at the same time as the riparian specialists to explore the observed patterns of riparian vegetation distribution in relation to hydrology and geomorphology.

Bed load and suspended sediment transport sampling was planned at three sites on the mainstem Klamath River: (1) in the J.C. Boyle peaking reach upstream of Copco reservoir (at the railroad boxcar bridge just upstream of the Shovel Creek confluence), (2) the Klamathon Bridge (or from catarafts at a better section nearby but above the Cottonwood Creek confluence), and (3) the bridge at the Interstate 5 (I-5) rest area (or from catarafts at a better section nearby). Sampling was originally planned to occur during the 2002 spring-summer snowmelt runoff, but snowmelt runoff in 2002 and subsequently in 2003 was so low that no spill occurred from the Project dams. Thus, snowmelt bed load sampling did not occur. In the 2002-2003 flow season, sampling occurred only in the J.C. Boyle peaking reach upstream of the Shovel Creek confluence because the river had sufficiently high flows for only a brief period. During 2003 sampling, bed load samples in the J.C. Boyle peaking reach were obtained at flows of approximately 3,000 cfs, which is the approximate flow release when both J.C. Boyle dam generators are running. At 3,000 cfs, the bed load transport rate was measured as 1.04 tons per day, and at 2,800 cfs it was measured as 0.6 ton per day. These samples support the results of the tracer gravel observations that the existing bed is not fully mobile at 3,000 cfs. The suspended load transport rate at 3,000 cfs was measured as 256 tons per day. Bed load sampling at the Klamathon Bridge and I-5 rest area sites will be conducted in 2004, depending on availability of sufficiently high flows.

Tracer gravels were placed in the Klamath River in the J.C. Boyle reach upstream of the Shovel Creek confluence, near the USGS gauge site below the J.C. Boyle powerhouse, near R-Ranch, above the Cottonwood Creek confluence, at the I-5 rest area, and in two tributaries (Shovel Creek and Humbug Creek) to document bed mobility during the 2002 snowmelt flow season. As flows were inadequate to produce movement of the tracer gravels (expected, given the lack of spill, and confirmed by observation of the tracer sites), these tracer gravel sites were revisited during fall 2002, winter 2003, and/or spring 2003 to confirm that tracer gravels were undisturbed, and to add tracer gravels to the J.C. Boyle bypass reach near the emergency overflow spillway and in the Frain Ranch area. Tracer gravels provide basic information on bed mobility at various flow levels and, with suitable assumptions, can be used to provide independent estimates of bed load transport rates (e.g., Kondolf and Matthews, 1986).

Streams tributary to the Klamath River deliver both bed load and suspended load to the mainstem. To assess these tributary bed load sources, a representative set of tributary delta deposits (formed where tributaries flow directly into Project reservoirs) was surveyed to quantify coarse sediment supply (particles greater than 2 mm) from tributaries. Surveys of tributary deltas included a combination of detailed bathymetric and terrestrial surveys to define the existing delta and to estimate pre-delta topography.

A sediment budget for the Project area was estimated using the various field measurements and observations, together with the insights gleaned from the aerial photograph analyses, sediment sampling, tracer gravel studies, and reservoir sedimentation studies. This sediment budget describes sediment production and routing through reservoirs and river reaches in the Project area, provides a framework to describe the relative importance of various sediment sources (both coarse and fine), and thereby provides a basic framework in which Project effects are evaluated.

E3.7.5.3 Results and Status

Reservoir Bathymetry

Bathymetry study results are described in detail in the Water Resources FTR, Section 6.0.

Conceptual Model of Potential Effects of Project Facilities on Sediment Transport and Channel Geomorphology

In general, the scientific literature reports that dams can affect sediment transport in one of two ways. When reservoirs are large enough to reduce floods, fine sediment from tributaries (and bank erosion and other sources) can accumulate on the bed downstream, because it is no longer flushed away by high flows. This fine sediment can infiltrate into salmonid spawning gravels and reduce incubation success (for sediments finer than about 1 mm) or affect the ability of fry to emerge from the gravel (for sediments about 1 to 10 mm in size) (Kondolf, 2000). This effect has been documented in many rivers, including the Trinity River below Lewiston dam, which is notable for the present study because it is one of the best-documented examples of this impact, and a downstream tributary to the Klamath River (Milhous, 1984). Reservoirs whose capacity is relatively small in relation to river flow typically allow high flows to pass, while still trapping gravels supplied from upstream. Downstream of such reservoirs, the bed may progressively coarsen as smaller gravels are transported downstream without being replaced (as previously) by gravels supplied from upstream. As a result, the bed may become dominated by larger gravels and cobbles that are unsuitable for use by spawning fish (Kondolf and Matthews, 1993).

Another downstream effect of reservoirs can be changes in the distribution of riparian vegetation brought about by changes in hydrology and the availability of sediments. Reduced flood flows can result in less active bed scour, erosion, deposition, and channel migration, resulting in smaller areas of fresh sediment surfaces available for colonization by seedlings of woody riparian species also less frequent scour and removal of seedlings from the active channel. Thus riparian vegetation can invade formerly scoured areas of the channel bed, but, over time, the riparian community may tend towards older individuals and later successional stage species, with less diversity of species and structure (Johnson, 1992).

Even if reservoirs do not significantly affect the high flows that erode and deposit sediment, they may affect the shape of the hydrograph during the seasons that riparian seedlings would normally establish, resulting in changes in the extent of riparian vegetation establishment (Rood and Mahoney, 1990). Moreover, changes in water quality (from upstream land uses and/or transformations within reservoirs) can potentially affect the growth of riparian vegetation through supply of nutrients for plant growth. Riparian vegetation is important as a resource in its own right, especially as it can provide important habitat to terrestrial and aquatic species, and it can affect geomorphic channel processes by increasing hydraulic roughness, inducing deposition on bars and along channel margins, and by changing the direction of flow.

Because the Project's reservoirs are relatively small compared with the Klamath River's annual runoff (e.g., Iron Gate reservoir impounds only 4 percent of annual runoff, and Copco No. 1 reservoir only 5 percent), and because the Project reservoirs are *not* operated for flood control, it is unlikely that they significantly affect high flows, except in bypassed reaches, i.e., reaches in which flows are reduced by diversion through penstocks for hydroelectric generation, such as the J.C. Boyle bypass reach and the Copco No. 2 bypass reach. Moreover, there were significant changes in how floods were routed between Upper and Lower Klamath Lakes a century ago, unrelated to the PacifiCorp Project. For example, construction of the railroad embankment (and USBR control gates) blocked flood overflow into Lower Klamath Lake, as had occurred formerly. Current USBR project facilities allow water management so that Upper Klamath Lake water in a flood situation can be moved to the Lost River system. Water can also be evacuated from Keno reservoir to the Klamath Irrigation Project via the ADY canal. These changes should have *increased* the magnitude of flood flows in the Klamath River below Keno dam compared with conditions prevailing before the late 19th century. These considerations suggest that coarsening of the bed has been a much more likely Project effect than accumulation of fine sediments. In bypassed reaches, the net effects of the dams would depend on the degree to which floods of various magnitudes have been reduced. For example, in the Copco No. 2 bypass reach, frequent floods have been so reduced that woody riparian vegetation has encroached onto formerly active gravel bars, while in the J.C. Boyle bypass reach any such effects have been more subtle.

To understand the possible direct effects of the Project on sediment supply, sediment transport, and channel form, it is also necessary to understand geologic controls and the effects of other historical human influences on channel form and processes, both present and past. The Klamath River has an unusual geologic setting, with strong geologic controls on channel form, and therefore the channel does not fit conventional assumptions about longitudinal profiles or downstream changes in alluvial channel form. Reflecting the geology of the reaches through which it flows, the Klamath River alternates from low gradient reaches above bedrock controls (such as near Keno dam) and steep bedrock reaches (such as the Keno reach). Examples of important human effects unrelated to the Project include diversion of flood flows from Lower Klamath Lake into the Klamath River at Keno dam mentioned above, the use of the river channel to float logs downstream, and the blasting of rocks from the channel to facilitate log floatation.

Analysis of Aerial Photographs

A comprehensive review of sets of aerial photography of the Klamath River in the Project area taken from 1944 to 2000 showed no significant systemwide change to the planform, bedforms, or channel geometry of the Klamath River. Some local changes were observed, including elimination of riparian vegetation and minor channel constriction in the J.C. Boyle bypass reach (associated with canal construction), development of an island in the J.C. Boyle bypass reach (associated with erosion at the emergency overflow spillway), and significant channel planform change downstream of Iron Gate dam (associated with past mining activities). Minor local changes to bedforms and channel geometry were also observed in alluvial reaches (e.g., J.C. Boyle peaking reach near Shovel Creek) but did not appear to be impacts from Project facilities or operations.

Delineation of Geomorphic Reaches

Measurements and observations at representative reaches were made in August 2002. Results and interpretation of this information is provided in the Water Resources FTR, Section 6.0. Distinct geomorphic reaches were identified and delineated (Link River, Keno, J.C. Boyle bypass, J.C. Boyle peaking – USGS Gauge to Frain Ranch, J.C. Boyle peaking – Gorge, J.C. Boyle peaking – Shovel Creek, Copco No. 2 bypass, Iron Gate dam to Cottonwood Creek, Cottonwood Creek to Scott River, and Scott River to Seiad Valley) that served as the framework for the assessment of Project impacts. These reaches were identified based on observations of geomorphic facies, channel geometry, long profile slope, bed material composition, and floodplain and riparian vegetation characteristics of the study sites distributed throughout the geomorphic reaches. Reaches in the Project area were classified as bedrock, plane bed, cascade, and pool-riffle under the Montgomery and Buffington system (1993), and as F, B, and C type channels under the Rosgen system (1994).

In general, the observations in these reaches describe a complex system that is strongly controlled in the Project area by local geology. Although local impacts from the Project have occurred, the kinds of systemwide impacts on large-scale geomorphic characteristics that have been documented in other rivers downstream of dams (e.g., Williams and Wolman, 1984) are not evident on the Klamath River. This is probably attributable to the nonalluvial (and sediment-supply-limited) nature of most of the river, which would tend to limit channel responses to Project-induced changes, and the difficulties in documenting changes that may have occurred, because of the high local variability resulting from strong local geologic controls.

Pebble count results indicate potential bed coarsening immediately downstream of Project dams and in the J.C. Boyle peaking and bypass reaches, but this impact is obscured by strong local geomorphic controls in the Project area that prevent the Klamath River from exhibiting a clear trend of downstream bed-sediment fining observed in most rivers. The assessment of large woody debris indicates that large wood plays a relatively minor role in large-scale geomorphic channel change.

Bed Load and Suspended Sediment Sampling

Bed load and suspended sediment sampling was originally planned to occur during the spring-summer 2002 snowmelt runoff, but snowmelt runoff in 2002 was so low that no spill occurred from the Project dams and thus snowmelt bed load sampling was postponed to the 2003 water year. Bed load in the J.C. Boyle peaking reach was sampled in April 2003 during a flow of approximately 3,000 cfs when both J.C. Boyle generators were running to test for possible effects of these hydroelectric-generation-induced fluctuating flows on sediment transport. The sampling indicated that small quantities of sand (approximately 1 ton per day at 3,000 cfs) are mobilized by flows within the range of control of the Project. Therefore, increased sand transport during peaking operations could be considered a direct Project impact. However, since gravel was not mobilized at 3000 cfs and sand starvation did not appear to be a major impact to geomorphology in the Project area, this result was not considered a major Project impact.

Tracer Gravel Study

Tracer gravels were placed in the Klamath River in the J.C. Boyle bypass reach near the emergency overflow spillway, J.C. Boyle reach in the Frain Ranch area, upstream of the Shovel Creek confluence, near the USGS gauge site below the J.C. Boyle powerhouse, near R-Ranch, above the Cottonwood Creek confluence, at the I-5 rest area, and in two tributaries (Shovel Creek and Humbug Creek) to document bed mobility. The results of the tracer gravel study suggest that the bed could be approaching the threshold of mobility at 1,500 cfs (the peak flow since the tracers were placed) in the J.C. Boyle bypass reach (RM 222), at 3,850 cfs (the peak hourly flow in 2003) near the USGS gauge (RM 219), and at 3,850 cfs near the Shovel Creek confluence (RM 206). No tracer movement was observed in 2002 when the peak hourly flow reached 3,000 cfs. The results of the tracer studies were used to calibrate the bed load transport calculations discussed below.

Tributary Delta Survey

Tributary delta survey field data collection was completed in April 2003. Results of the tributary delta survey provided the basis for extrapolation of sediment inputs from all tributaries to the Klamath River in the Project area. The deltaic formations of several tributaries that flow directly into Iron Gate reservoir and one that flows directly into J.C. Boyle reservoir were surveyed and compared with pre-reservoir topography to estimate the volume (and mass) of bed material (includes bed load and some suspended load) delivered since the completion of the dam. This was then used to calculate an average annual sediment yield per unit area that was applied with adjustment factors to all other tributaries in the Project area. Total sediment yields estimated for each reach ranged from hundreds of tons per year in the Link River reach to tens of thousands of tons per year in the J.C. Boyle reach. Sediment yields were significantly higher downstream of Iron Gate dam.

Bed Mobility and Bed load Transport Capacity

The results of the frequency of bed mobility analysis were based on a with-Project condition with recorded hydrology and active elements of the bed characterized by their current median particle diameters, and a without-Project condition with hydrology adjusted to remove reservoir storage and active elements of the bed characterized by median particle diameters characteristic of tributary sediments. The with-Project condition was mobile less frequently in all reaches downstream of J.C. Boyle dam in this analysis.

Average annual bed load transport capacities were estimated for the sediment budget (using with-Project hydrology and without-Project active feature median particle sizes) and were in the hundreds of thousands of tons per year upstream of Iron Gate dam. However, transport capacities ranged from zero in dry years to millions of tons per year in wet years. Calculated bed load transport capacities were significantly lower downstream of Iron Gate dam, probably because of dimensionless critical shear stress values derived from tracer gravel observations upstream. It is likely that actual bed load transport capacities downstream of Iron Gate dam are higher than the values presented.

In the Klamath River upstream of Iron Gate dam, transport capacity is, on average, one to two orders of magnitude greater than the sediment yield from tributaries. This result supports the qualitative assessment of the Klamath as a historically sediment-starved system.

Sediment Sources and Sediment Budget

The primary sediment sources to the mainstem Klamath River were from tributaries. Less than 2 percent of the total sediment inputs came from landslides directly into the channel. Important sources of fine sediment from the erosion associated with the emergency overflow spillway in the J.C. Boyle reach were quantified in this reach and included in the sediment budget for the Project area.

The primary Project impact on geomorphology and sediment transport is the capture of bed load material delivered from tributaries by Project reservoirs. The sediment budget gives an average annual quantity of sediment that would be transported to downstream reaches without capture by the Project reservoirs. In part because of this effect, gravel augmentation is proposed as an enhancement measures, as described in Section E4.0 of this Exhibit E.

Alluvial features, and flow and sediment inputs, were also estimated for the Klamath River below Iron Gate dam (to about the confluence with the Scott River) and then compared to flow changes and sediment capture upstream of Iron Gate dam. This comparison suggests that Project impacts on the geomorphology of the Klamath River below Iron Gate dam are minor relative to inputs and effects separate from the Project, and that accrual to the river of sediment and flow inputs overwhelm any Project-related effects by the Shasta River, and certainly by the Scott River.

E3.7.6 Monitoring and Analysis of Water Quality During Project Maintenance Operations (Study 1.6)

E3.7.6.1 Purpose

Routine maintenance activities are a controllable aspect of Project operations that could affect water quality in the Project area. The activities are associated with annual maintenance of the Project's waterway facilities (e.g., canals), with surface water spill from Project reservoirs during maintenance, and with inspection and maintenance of roads and culverts in the Project area. PacifiCorp conducted water quality sampling and analysis during such events to determine the specific effects that these maintenance activities might have on water quality in the Project area. The information from this sampling and analysis enabled PacifiCorp to identify whether, where, and when maintenance activities affect water quality, and to further identify appropriate measures to protect water quality.

E3.7.6.2 Methods

In 2002, PacifiCorp monitored water quality during annual maintenance events. Additional monitoring occurred in June 2003 for a maintenance event at the J.C. Boyle canal. Water quality parameters evaluated during these activities included dissolved oxygen, temperature, pH, turbidity, conductivity, and TDG. Maintenance studies have been performed on the Link River, Copco No. 2 bypass reach, J.C. Boyle bypass and peaking reaches, and the mainstem Klamath River below Iron Gate dam.

Monitoring consisted of deployment of multiparameter probes (either YSI 6920© or Hydrolab©) prior to maintenance activities to establish baseline conditions. Following the initiation of the maintenance activity, data collection continued to capture any change in the selected parameters. Additional spot checks with a multiparameter water quality probe were taken to cross-check the data from the deployed instruments and to provide data if equipment malfunctions occurred. The logging equipment was set to record data at intervals of 1 hour or less, depending on the scope of the maintenance event. Spot measurements of total dissolved gas measurements were taken at J.C. Boyle, Iron Gate, Link River, and Copco No. 2 dams.

All water quality testing equipment was calibrated to manufacturer specifications prior to deployment. In-situ calibration for dissolved oxygen was performed to correct for local barometric pressure. Following data collection and download, postcalibration was performed to determine the reliability of the data and to identify if "drift" in parameter values occurred.

PacifiCorp inventoried and assessed road and culvert conditions extending from Link River dam to Iron Gate dam within the FERC Project boundary. Additional road condition data have been supplied by BLM for the J.C. Boyle peaking reach, although culverts are not included in the data set. The area of effect used in assessing potential sedimentation impacts of Project roads and culverts on water quality contained in this study was defined geographically as ¼ mile from Project waterways, including canals, riverine habitat, and reservoir habitat.

E3.7.6.3 Results

Details on results of this study are provided in the Water Resources FTR, Section 7.0.

Maintenance Events

Maintenance at the East Side facility, requiring spill in the Link River bypass reach, took place May 9-22, 2002. Maintenance caused an increase in turbidity following the spill release at Link River dam. Turbidity increased beyond the background mean at this site (12.3 NTUs) for a period of 27 hours before dropping back down to levels at or below background. Dissolved oxygen data collected at both locations show an overall decrease, although minor, in average values with the increased flow in the Link bypass reach. TDG measurements were taken below Link River dam before and during the planned spill event. Percent saturation differed only by 3 percent between minimal (90 cfs) and maintenance spill. Readings were 99 and 102 percent for the minimal and full spill releases, respectively.

J.C. Boyle canal maintenance activities occurred during September 12-15, 2002. Diversion of flow and peaking operation did not occur during this period, resulting in spill at J.C. Boyle dam and high flow releases to the J.C. Boyle bypass reach. A change in average water temperature related to this maintenance event was seen at the lower end of the J.C. Boyle bypass reach, where an increase of 1.71°C occurred. Increased flows in the J.C. Boyle bypass reach from the maintenance event decreased the range of diel temperature fluctuations; however, temperatures remained within the range of the pre-event values. The maintenance event had a relatively minor influence on dissolved oxygen and pH values.

Turbidity levels increased at the upper end of the J.C. Boyle bypass reach following spill for a period of 8 hours until receding to pre-event values. Turbidity levels at the lower end of the bypass reach increased above the average pre-event values for a total of 15 hours, although the values were lower than those recorded in the upper reach for the same period. There was no effect from the maintenance on turbidity measured in the J.C. Boyle peaking reach. TDG measurements were taken during the spill event in two locations within the bypass reach. TDG measured 99 percent at the upper end of the bypass reach, and a value of 100 percent was measured at the lower end of the bypass reach, just upstream of the powerhouse.

Construction took place on the J.C. Boyle canal headgate during June 13-19, 2003, requiring shutdown of J.C. Boyle canal and powerhouse operations. This action required surface spill from the J.C. Boyle reservoir into the bypass reach to meet flow needs below Iron Gate dam (the flow in the bypass reach equaled the flow in the peaking reach). Spill at J.C. Boyle dam increased water temperatures by about 2°C in the lower bypass reach through the duration of monitoring. This was caused by the dilution of the relatively cool springs in the bypass reach by the relatively warmer spill waters. The site upstream of Shovel Creek in the peaking reach exhibited a minor decrease in duration of the maximum daily temperature for the day of the first release, with no other discernible effects after that. No effect on temperature was apparent in the data collected below Iron Gate dam, probably due to the lag in water travel time and the influence of Copco and Iron Gate reservoirs.

This maintenance event had a minor to indiscernible effect on dissolved oxygen and pH values. An obvious increase in turbidity occurred at the upper end of the bypass reach in response to spill at the J.C. Boyle dam. Minor elevated readings occurred in both the lower bypass reach and the peaking reach above Shovel Creek. No detection of turbidity effects caused by maintenance activities were perceived below Iron Gate dam. TDG readings were taken below the J.C. Boyle spillway on June 17, 2003. A measurement of 103 percent saturation was recorded, coinciding with an approximate flow of 280 cfs at this location.

Iron Gate dam maintenance was performed during May 16-26, 2002. All water released from Iron Gate dam during this maintenance event was passed through the spillway. Klamath River flows below Iron Gate dam during maintenance ranged from 1,719 to 1,490 cfs. Water temperatures were slightly higher at the beginning of maintenance but remained fairly stable (ranging from 12.2° to 16.3°C) thereafter. Dissolved oxygen measurements were above 8.5 mg/L throughout the maintenance period, and pH remained fairly stable (ranging from 8 to 9). Turbidity only changed by a total of 2.4 NTUs through the duration of the event. TDG was recorded while in spill mode and again at the time of unit startup. Total percent saturation only differed by 1 percent between nonspill (104 percent) and maintenance spill (103 percent) operations.

Project Roads and Culverts

Of the 253 miles (407 km) of road systems identified within the road inventory study area, approximately 20 percent (95 km) are on PacifiCorp property. The existing FERC Project boundary contains 48 miles (77 km) of roadway, of which only 55 percent (42.5 km) is on PacifiCorp land. Only unpaved roads were assessed for potential water quality impacts in the discussion provided below.

PacifiCorp identified 268 culverts within ¼ mile of Project waterways. About 80 percent of the culverts were found to be in good condition. Partially crushed culverts were identified at 14.5 percent of the sites, culverts with significant rusting made up 3.3 percent of the culverts inventoried, while totally crushed culverts were found 1.1 percent of the time (three sites). Only one culvert was found to be completely nonfunctional, with water flowing around it.

Roadways identified in the area of concern totaled 1,212,982 linear feet. Unpaved roads contributed to 79.9 percent of the total (969,352 linear feet). Fifty-six percent of the roads were considered to be in good condition, while 12.3 percent, 5.3 percent, and 3 percent had rutted, washboard, and eroded conditions, respectively. Roads exhibiting erosion were mainly found on the west side of Link River and the south end of Keno reservoir, a road commonly used by the public for fishing access. Further erosion concerns and rutted roads were documented on the west and north banks of J.C. Boyle reservoir and are mainly associated with off-highway vehicle use. Roads exhibiting washboard conditions were scattered through out the study area.

PacifiCorp will continue to use best management practices for the maintenance of these roads and culverts, reducing the potential of impacts on aquatic habitats. Further refinement of these best management practices, including site-specific planning, will result from this analysis.

E3.7.7 Fall 2002 Macroinvertebrate Study (Study 1.11)

E3.7.7.1 Purpose

The purpose of this study was to conduct a bioassessment of macroinvertebrates in the Project area during fall 2002. The bioassessment was used to determine the presence and composition of macroinvertebrate taxa. This information was used to (1) assess the potential relationship of macroinvertebrate community composition to water quality conditions; (2) assess the presence of designated Species of Concern;[25] (3) determine the quality of the macroinvertebrate assemblage as a food source for fish and wildlife; and (4) identify susceptibility of macroinvertebrate taxa to flow changes.

E3.7.7.2 Methods

PacifiCorp used the CSBC and the CLBP protocols to evaluate macroinvertebrates as appropriate throughout the study area. The CSBP and CLBP protocols have been adapted from the EPA's Rapid Bioassessment Protocols by the CDFG Aquatic Bioassessment Laboratory (CDFG, 1999a and 1999b). The CSBP is a standardized protocol for assessing biological and physical/habitat conditions of wadeable streams in California (CDFG, 1999a). The CLBP is a standardized

[25] The U.S. Fish and Wildlife Service has designated the following macroinvertebrate as Species of Concern that could occur in the Project area: *Apatania (=Radema) tavala* (Cascades apatanian caddisfly), *Homoplectra schuhi* (Schuh's homoplectran caddisfly), and *Rhyacophila mosana* (Bilobed rhyacophilan caddisfly).

protocol for assessing biological conditions of still water environments, such as reservoirs and lakes (CDFG, 1999b).

Macroinvertebrate samples were collected in 21 lotic riverine reaches along the Klamath River from Link River dam (RM 254.3) to the mouth of the Shasta River (RM 176.7). Six additional stream reaches were sampled in Fall Creek. Four reservoirs on the mainstem Klamath River were sampled within this study reach. Details on methods for this study are contained in Section 8.0 of the Water Resources FTR and are summarized in section E3.3.

E3.7.7.3 Results

Details on results of this study are presented in Section 8.0 of the Water Resources FTR, and are summarized in section E3.3.2.7. In discussions with the Water Quality Work Group, it was determined that additional macroinvertebrate sampling would be done during spring 2003, focusing on key river reaches of most concern in the Project area. The purpose and methods of the study titled Spring 2003 Macroinvertebrates Study is described in section E3.7.11.

E3.7.8 Determination of Sediment Oxygen Demand in Selected Project Reservoirs (Study 1.13)

E3.7.8.1 Purpose

The purpose of this study was to collect undisturbed sediment cores from sites in the Project reservoirs and to measure, in the laboratory, the rate of consumption of oxygen from the overlying water and the rate of release of nutrients from the sediment to the overlying water. The information gathered through this work was used to specify the sediment oxygen demand and sediment nutrient release rates used in the water quality models (as described in the Water Resources FTR, Section 4.0).

E3.7.8.2 Methods

Sediment samples were collected from locations in each of four reservoirs:

- Lake Ewauna/Keno reservoir
- J.C. Boyle reservoir in the deepest area near the dam
- Copco No. 1 reservoir in the deepest area near the dam
- Iron Gate reservoir in the deepest area near the dam

The sediment samples were collected as intact sediment cores (between 20 and 30 cm sediment depth) that were transported to the laboratory for incubation and water quality sampling. At each site, sediment cores were collected using a 10-cm-diameter, sphincter-coring device for collecting undisturbed cores from unconsolidated sediments. The objective was to collect duplicate cores at each site. The sediment cores were wrapped in insulating material to prevent excess warming and placed in upright stands for transport to the laboratory. Once the cores reached the laboratory, the core bungs were replaced with seals that allowed sampling of the overlying water without exposure to the air.

Sediment oxygen demand and nutrient flux rates were determined by using the core collection tubes as core flux incubation chambers. Multiple water samples were collected from the water above the sediment over a period of several days to develop estimates of rates for oxygen uptake and sediment release rates from the sediments. Water samples were analyzed for constituents of particular importance to the needs of the water quality models, including water temperature, pH, redox potential, specific conductance, dissolved oxygen, orthophosphate, nitrate, ammonia, iron, manganese, and sulfur (see the Water Resources FTR, Section 9.0, for details).

E3.7.8.3 Results

Dissolved oxygen decreased linearly for the first 72 hours of the study, at which point the system actually became anaerobic. Oxygen demand during the first 48 hours of incubation, as a function of sediment surface area, varied from 1.5 to 4.7 $g/m^2/day$. The rapid rate of oxygen depletion in Lake Ewauna, Keno reservoir and J.C. Boyle reservoir can be attributed largely to the BOD of the water. Water from Upper Klamath Lake enters the Project area with a substantial oxygen demand, presumably derived from decomposition of the entrained cyanobacteria. The oxygen demand in the upper portion of the Project area appears to overshadow the effects of the sediment to a considerable degree. This is evident when the BOD demand in the overlying water was plotted as a percentage of the available oxygen in the aerated cores.

The results indicate that there is sufficient BOD in the overlying water to consume most or all of the oxygen in the core tubes without invoking uptake from sediment oxygen demand. Clearly, these sediments exert an oxygen demand, but the primary effect is from the water, not the sediments. In Copco and Iron Gate reservoirs, BOD is low and sediment effects become a more important influence on the quality of the overlying water.

The in-situ results for all samples were plotted as a function of time versus concentrations or constituent value. The results show that most of the short-term oxygen demand in the system can be accounted for on the basis of the decaying organic matter in the water column. Denitrification proceeded during and following O_2 reduction. Following the loss of O_2 and NO_3 from the overlying water, changes in the other measured constituents were governed by redox conditions. These included release of Fe^{+2}, Mn^{+2}, PO_4^{2-}, and NH_4^+ and loss of S to SO_4^{2-} reduction.

The results indicate that the oxygen dynamics of the upper study area, especially Lake Ewauna and Keno reservoir, are controlled to a large extent by the nature of the water entering the system rather than sediment-water interactions in the impounded areas. Where anaerobic conditions exist for extended periods, nutrients and other constituents can be released from the sediment. Such effects may play a larger role in water quality dynamics in the hypolimnion in Copco and Iron Gate reservoirs. These results demonstrate the importance of redox potential (E_H) as a routine parameter in future monitoring programs. The dissolved oxygen data are important, but these results demonstrate that the redox condition of the waters affects the release of phosphorus and ammonia into the overlying waters.

E3.7.9 Screening Level Determination of Chemical Contaminants in Fish Tissue in Selected Project Reservoirs (Study 1.14)

E3.7.9.1 Purpose

This study was a Tier I (screening level) study of the Project reservoirs. The primary aim of this study was to identify whether certain fish species are bioaccumulating toxic substances at levels that may adversely affect public health or wildlife via fish consumption, or be harmful to aquatic life (based on existing quality criteria/guidelines for the protection of human health, wildlife, and aquatic life).

E3.7.9.2 Methods

The primary target species in all reservoirs was largemouth bass. In addition, bullhead was a primary target species in Keno reservoir. Fish samples were collected from various locations in each of the reservoirs of the Project: Keno reservoir (including Lake Ewauna area), J.C. Boyle reservoir, Copco reservoir, and Iron Gate reservoir. Samples were also collected from Klamath Lake to be used as a reference for background conditions.

The methods used for sample collection, handling, and analysis were developed with input from toxicologists from ODEQ and CDFG based on chemicals known to be used on the Klamath Irrigation Project. They follow guidance documents issued by EPA.[26] Fish were collected and handled using proper techniques and protocols recommended by the CDFG Water Pollution Control Laboratory. Fish were collected using a variety of methods, including electroshocking, nets, and angling. Fish used for analysis included the largest specimens of at least legal size customarily caught by recreational anglers or subsistence fishers. Fish for analysis were tagged, labeled, wrapped in aluminum foil, sealed in plastic, frozen immediately in the field, and shipped overnight to the laboratory for analysis. Length and weight were recorded for all fish used in the analysis.

Tissue samples were analyzed by the CDFG Water Pollution Control Laboratory in Rancho Cordova, California. Two composite samples comprising six fish each of the primary target species were analyzed for each reservoir. The tissue to be analyzed consisted of fillets with skin[27] for fish caught in both California and Oregon. Tissue composites were homogenized and analyzed for total lipids, pesticides, polychlorinated biphenyls (PCBs), and selected metals. Metals analysis included arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc.

The methods were intended as a screening-level analysis of existing conditions. Should any proposed mitigation or enhancement measure or change in operations lead to significant disruption of sediments in the Project reservoirs, additional studies of potentially toxic contaminants may be developed in cooperation with the relevant state agencies.

E3.7.9.3 Results

Fish were collected during May-June 2003. The subsequent laboratory analysis of chemical contaminants in fish tissue has not yet been completed. Results of this sampling and analysis, when available from the CDFG Fish and Wildlife Water Pollution Control Laboratory, will be presented in a separate final study report.

[26] EPA 823-B-00-007, November 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition. Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

[27] EPA Guidance recommends using skin-on fillets. The state of California prefers skin-free fillets because of the great difficulty in obtaining uniform homogenates with skin-on fillets (Gassel, California Office of Environmental Health Hazards Assessment, pers. comm.).

E3.7.10 Investigation of Klamath River Freshwater Bivalves in the J.C. Boyle Peaking Reach and Downstream of Iron Gate Dam (Study 1.19)

E3.7.10.1 Purpose

The basic objective of this proposed study was to better understand the relative abundance, diversity, distribution, and evidence of recruitment of bivalves in the J.C. Boyle peaking reach and the Klamath River from Iron Gate dam to the confluence of the Shasta River. Information collected refines information from previous studies that generalized the distribution of bivalves in the California section of the Klamath River (Taylor, 1981). Although detailed previous work existed for the Oregon section of the Upper Klamath River Basin (Frest and Johannes, 1998, 2000), very little work had previously been performed to identify species in the mainstem Klamath River below the J.C. Boyle powerhouse to the California border.

E3.7.10.2 Methods

Methods consisted of a modified form of the BLM Aquatic Mollusk Survey Protocol developed for the Northwest Forest Plan (1994). Since bivalves are the target species of interest for the surveys, a microhabitat approach to sample site selection was used. The protocol developed for aquatic mollusks under the Northwest Forest Plan includes techniques for the capture of all of the aquatic mollusk species, covering a range of habitat types. Since not all of the aquatic mollusk species are of interest in this proposed study, only appropriate portions of the protocol were used. Variations from the protocol occurred in the following: (1) selection of sample sites, (2) equipment used to capture the species, and (3) species enumeration.

The main focus of this study was on the larger bivalve species, which include *Anodonta oregonensis* (Oregon floater), *Margaritifera falcata* (western pearlshell), *Gonidea angulata* (western ridgemussel), and *Anodonta californiensis* (California floater).

The geographic scope of the study included the J.C. Boyle peaking reach from the J.C. Boyle powerhouse to Copco reservoir and the mainstem Klamath River from Iron Gate dam downstream to the confluence of the Shasta River. Reservoir areas were not included in this riverine survey. PacifiCorp also investigated locations in the Keno reach where large bivalves have been observed by ODFW (Smith, ODFW, pers. comm.).

E3.7.10.3 Results

Sample reach identification through review of stream inventory data and other sources occurred in May-June 2003. Site reconnaissance, field surveys, and voucher specimen collection occurred in July-August 2003. Details on results are included in Section 11.0 of the Water Resources FTR and are summarized in section E3.3.2.7.

E3.7.11 Spring 2003 Macroinvertebrates Study (Study 1.20)

E3.7.11.1 Purpose

The purpose of this study was to conduct a bioassessment of macroinvertebrates in the Project area during spring 2003.[28] This bioassessment was conducted as follow-up to a bioassessment of macroinvertebrates in the Project area during fall 2002 (see section E3.7.3). The information from both the fall 2002 and spring 2003 assessments provides information to (1) assess the potential relationship of macroinvertebrate community composition to water quality conditions; (2) assess the presence of designated Species of Concern; (3) determine the quality of the macroinvertebrate assemblage as a food source for fish and wildlife; and (4) identify susceptibility of macroinvertebrate taxa to flow changes. The fall 2002 sampling helps to assess seasonal differences in the presence and composition of macroinvertebrate taxa, and the potential effects on these taxa from seasonal differences in flow and water quality conditions.

E3.7.11.2 Methods

The spring 2003 sampling was conducted in the following sections of the Klamath River in the vicinity of the Project: (1) Keno dam to J.C. Boyle reservoir (Keno reach); (2) J.C. Boyle dam to powerhouse (J.C. Boyle bypass reach); (3) J.C. Boyle powerhouse to Copco No. 1 reservoir (J.C. Boyle peaking reach); and (4) Iron Gate dam to the confluence with the Shasta River. This sampling effort was reduced from the more comprehensive study conducted in Fall 2002. In discussions with the Water Quality Work Group, it was determined that the spring 2003 sampling could focus on key river reaches of most concern in the Project area, and that the number of reaches and samples as proposed was sufficient for comparing with fall 2002 results to assess potential seasonal differences in macroinvertebrate community composition.

As with the fall 2002 macroinvertebrate sampling, the CSBP was also used for the spring 2003 sampling. The CSBP protocols have been adapted from the EPA's Rapid Bioassessment Protocols by the CDFG Aquatic Bioassessment Laboratory (CDFG, 1999a). The CSBP is a standardized protocol for assessing biological and physical/habitat conditions of wadeable streams in California (CDFG, 1999a). ODEQ indicated that use of the CSBP protocols would be acceptable.[29]

E3.7.11.3 Results

Field data collection occurred in May 2003. Laboratory processing of samples occurred in summer 2003. Details on results are included in Section 12.0 of the Water Resources FTR and are summarized in section E3.3.2.7.

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[28] Sampling occurred over a several day period during May 2003.

[29] Use of the CSBP protocols was indicated as acceptable in a letter dated March 19, 2002, from Paul DeVito (ODEQ) to Todd Olson (PacifiCorp).

E3.7.12 Analysis of Potential Project Effects on Water Quality Aesthetics (Study 1.22)

E3.7.12.1 Purpose

The purpose of this study was to assess how water quality affects aesthetic conditions in the Project area and infer how the Project may contribute to these water-quality-related aesthetic conditions. For example, a Klamath Recreation User Survey was conducted in the Project area 2001 (see Recreation Resources FTR). The survey did not ask questions directly relevant to Oregon water quality criteria or California water quality objectives; however, some respondents offered comments concerning water quality.

E3.7.12.2 Methods

The effect of water quality conditions on aesthetics and the relative Project contribution to these conditions was assessed in two primary steps. In the first step, information from the Klamath Recreation User Survey (see Recreation Resources FTR) was used to summarize responses to questions regarding perceptions of water quality conditions and effects on user experience. From this information, the specific factors contributing to the perceived water quality condition or effect were determined. The survey was not designed to correlate user responses on water quality conditions to specific, quantified water quality conditions at the time of the response. Nevertheless, the survey was considered adequate to determine whether the user's experience was affected by water quality conditions and to identify factors causing the water quality conditions cited by users.

In the second step, for the factors identified in the first step, water quality modeling (described in Study 1.3) and water quality data trend analysis (based on data obtained in Study 1.1 and Study 1.2) were used to draw inferences regarding potential Project effects on these factors. Since the model obviously does not directly predict aesthetics, this was done primarily by using model results for parameters that are surrogates for the aesthetics factors identified in the first step (e.g., nutrients and algae). This was done by comparing the results from the model for these parameters for existing conditions and hypothetical without-Project scenarios. The analysis of water quality data (e.g., turbidity, chlorophyll *a*, total suspended solids) consisted primarily of nonparametric exploration of data trends, distributions, and site comparisons.

Some stakeholders requested that PacifiCorp also analyze whether changes have occurred in water quality aesthetics since wild and scenic designation in the early 1980s. PacifiCorp will examined available turbidity, algae (i.e., chlorophyll *a*), and Secchi disk data since 1980, together with flow data, to determine if there are any obvious trends in the data over that period. The data were partitioned or adjusted to account for variation due to season or river discharge rate.

E3.7.12.3 Results

Twenty-six percent of respondents in a survey of recreational users in the Project area stated that water quality had detracted from their visit.[30] A summary of their responses is included in Table E3.5-8. Most of the comments indicated that algae or aquatic plants ("algae, green stuff,

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30 Results of the survey are available at http://newwww.pacificorp.com/file/file24051.pdf on the PacifiCorp website.

muck, seaweed, moss, slime") and the attendant odor were the cause of the negative experience. Other factors mentioned included dead fish and turbidity caused by powerboat operations.

The analysis of potential Project effects on water quality aesthetics using water quality modeling and water quality data trend analysis has not been completed (as of the date of preparation of this Exhibit E). PacifiCorp plans to complete this analysis by the end of April 2004.

E3.7.13 Proposed Studies

No other additional water quality studies are proposed.

E3.7.14 Outstanding Study Issues

No outstanding study issues are identified.

E3.8 PROPOSED ENHANCEMENT MEASURES FOR WATER USE AND QUALITY

PacifiCorp proposes to implement enhancement measures for water use and quality on the Project as described in this section. The descriptions of the measures include an explanation of their rationale and plans for their implementation. In some cases, further discussion of the measures with agencies and stakeholders is planned before plans are finalized. Such further discussions, if applicable, are also described below. In particular, PacifiCorp expects that water quality measures will be refined as consultation and coordination continues on the CWA Section 401 water quality certification process for the Project.

The descriptions below include a case in which potential measures are described but not formally proposed. In this case—i.e.,Iron Gate low-level withdrawal for downstream temperature management—measures are not proposed for the FERC license at this time. Hypolimnetic cool water storage is available in Iron Gate reservoir, but the volume of this cool water is limited. As a result, the potential benefit from releases of this cool water for temperature reduction downstream is likewise limited and may lack practicality. Before committing to this measure, PacifiCorp will consult further with CSWRCB during the Section 401 water quality certification process for the Project (described in section E3.4.

E3.8.1 East Side and West Side Facilities Decommissioning

E3.8.1.1 Proposed Measure

The East Side and West Side facilities will be decommissioned. The forebay and intakes that currently supply water from Link River dam to the East Side and West Side facilities will be rendered inoperable. Downstream of intake gates, concrete watertight bulkheads will be constructed. Forebay walls and spillway and intake structures will be removed. Penstocks and flowlines will be dismantled and removed from the site along with their associated support structures. The steel surge tank the East Side powerhouse and the concrete support pedestal will also be removed. All areas that have been disturbed will be regraded and hydroseeded.

Any components of the East Side and West Side powerhouses associated with power generation that contain chemical or hazardous materials, including transformers, batteries, tanks, and asbestos-based products will be removed from the site. All windows and doors will be sealed to prevent public access. The incoming potable water lines will be disconnected and the septic systems will be disconnected and backfilled. The penstocks to the turbine and the draft tube discharge will be sealed, assuring that access is prevented. The transmission line (No. 56-8) from East Side powerhouse to a tap-point on transmission line 11 will also be removed.

E3.8.1.2 Associated Water Quality Protection or Enhancement

Current operations of the East Side and West Side facilities divert flows from a portion of Link River, as described in section E3.1. With the proposed measures, such flow diversions will cease.

Current operations of the East Side and West Side facilities have no adverse effects on water quality conditions in Link River, as evidenced by water quality monitoring and modeling results described in the Water Resources FTR, Sections 3.0 and 4.0. With the proposed measures, any effect whatsoever on water quality will be eliminated.

Decommissioning of the East Side and West Side facilities will be conducted so as to properly dispose of any chemical or hazardous materials and properly disconnect water lines and septic systems. All areas that have been disturbed during decommissioning activities will be regraded and hydroseeded to prevent erosion.

E3.8.2 Instream Flow and Ramping Rate Measures

E3.8.2.1 Proposed Measures

Instream flow and ramping rate measures are implemented to protect and/or enhance various flow-dependent resources, including water quality. Instream flow and ramping rate measures applicable to the various reaches affected by the Project are described below by Project development or major river reach. For a comprehensive discussion of these flow measures from an aquatic resources perspective, see section E4.8 of this Exhibit E. For a comprehensive discussion of these flow measures from a recreation resources perspective, see section E7.8 of this Exhibit E. Also, as described in section E4.8, PacifiCorp has agreed to continue requested analysis and discussion with stakeholders on instream flow needs for aquatic resources. Based on these discussions, PacifiCorp may choose to formally modify its proposed flow and ramping rate measures.

Link River

As described above, the East Side and West Side Developments will be decommissioned. As such, they will no longer be diverting flow from, or ramping flows in, Link River. Therefore, no revised instream flow schedule and no revised ramp rates are proposed for Link River. USBR, as owner and operator of the Link River dam, will be responsible for meeting any flow requirements downstream of Link dam.

Keno

Keno facilities and operations are not proposed for inclusion in the new FERC license as this development does not generate electricity and does not substantially benefit generation at PacifiCorp's downstream hydroelectric facilities. Following this FERC relicensing process, PacifiCorp plans to consult with the state of Oregon on operations of Keno dam, as required by state regulations.

J.C. Boyle Bypass Reach (J.C. Boyle Dam to Powerhouse)

A minimum flow of 100 cfs will be released from J.C. Boyle dam at all times to enhance usable fish habitat while maintaining high water quality in the J.C. Boyle bypass reach. This release will result in a minimum instream flow of roughly 320 cfs at the lower end of the bypass reach due to the input of approximately 225 cfs of spring flow within this reach.

Downramp rates will not exceed 150 cfs per hour, except for flow conditions beyond the Project's control (e.g., inflows to the J.C. Boyle reservoir that change at rates greater than above ramp rate). This rate is primarily applicable to planned maintenance events. To the extent possible, flow changes will occur during the night to reduce the risk of potential fish stranding associated with river spill events.

J.C. Boyle Peaking Reach (J.C. Boyle Powerhouse to Copco Reservoir)

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

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

Flow upramp rates will not exceed 9 inches (in water level) per hour. Flow downramp rates will not exceed 9 inches per hour for flows above 1,000 cfs, and will not exceed 4 inches per hour for flows less than 1,000 cfs (as measured at USGS Gauge No. 11510700 downstream of the J.C. Boyle powerhouse).

Peaking operations will continue at the powerhouse. However, the daily Project-controlled flow change (i.e., the difference between lowest and highest flow in a 24-hour-period) during peaking operations will not exceed 1,400 cfs (as measured at USGS Gauge No. 11510700 downstream of the J.C. Boyle powerhouse). The limit of flow change to 1,400 cfs per daily period will preclude no load to full two-unit peaking events during low to medium river flow periods (i.e., when flows are less than about 1,800 cfs at Iron Gate dam). This will provide greater flow stability for aquatic resources but continue to provide a balance of whitewater boating and angling opportunities (periods of optimal wading-based fishing and standard whitewater boating flows), as one unit can provide raftable flows. Low flow periods (i.e., flows of 700 cfs or lower at Iron Gate dam) will have limited one-unit peaking time "windows" for standard whitewater boating (which relies on flows of 1,500 to 1,800 cfs). Anglers will conversely have larger time windows for angling opportunities.

Two-unit operation will occur if inflows are high enough to run both units, or to run one unit in continuous operation and operate the second one in peaking fashion. Peaking of the second unit will only occur while the first unit is in operation and flows for such operation will only occur at medium-high to high flow periods (i.e., flows of 1,800 cfs and higher at Iron Gate dam).

Copco No. 2 Bypass Reach (Copco No. 2 Dam to Powerhouse)

A minimum flow of 10 cfs will be released from Copco No. 2 dam at all times. Downramp rates will not exceed 125 cfs per hour, except for flow conditions beyond the Project's control (e.g., inflows to the J.C. Boyle reservoir that change at rates greater than above ramp rate). This rate is primarily applicable to planned maintenance events. To the extent possible, flow changes will occur during the night to reduce the risk of potential fish stranding associated with river spill events.

Klamath River Downstream of Iron Gate Dam

The instream flow schedule below Iron Gate dam will be maintained according to USBR's Klamath Irrigation Project Operations Plans consistent with BOs issued by USFWS and NOAA-Fisheries, as will current ramp rates below Iron Gate. These instream flows and ramp rates have been developed based on extensive study and BOs issued by USFWS and NOAA-Fisheries to protect ESA-listed species. Both are measured at USGS Gauge No. 11516530 just downstream of Iron Gate dam).

The instream flow scheduled stipulated in the latest Klamath Irrigation Project 2003 Operations Plan (April 10, 2003) is listed in Table 3.1-13. The 2003 Operations Plan includes the following downramping criteria at Iron Gate dam: (1) decreases in flows of 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period when Iron Gate dam flows are above 1,750 cfs; and (2) decreases in flow of 150 cfs or less per 4-hour period and no more than 50 cfs per 2-hour period when Iron Gate dam flows are 1,750 cfs or less. Absent the ESA obligations, ramp rates will be consistent with Hunter (1992) and will be 2 inches per hour as measured at USGS Gauge No. 11516530.

Fall Creek

A minimum flow of 5 cfs will be released into the Fall Creek bypass reach, and a minimum flow of 15 cfs will be released downstream of the bypass confluence. A release structure will be constructed to maintain the continuous 5 cfs release at the diversion dam. The increase to a minimum flow of 5 cfs in the bypass reach is aimed at enhancing usable habitat for resident trout.

Spring Creek

A minimum flow release to the Spring Creek bypass reach will be provided at the Spring Creek diversion (to Fall Creek). A specific release amount has not yet been determined and will be developed in consultation with appropriate federal and state agencies. Studies will be completed to identify the appropriate minimum instream flow for the Spring Creek bypass reach. It is expected that upon completion of the studies and consultation with appropriate agencies a minimum instream flow will be identified that balances power and nonpower resources, including water quality.

E3.8.2.2 Associated Water Quality Protection or Enhancement

Instream flow and ramping rate measures as proposed will protect and/or enhance various flow-dependent resources, including water quality. For a comprehensive discussion of the protection of fish resources, see section E4.8 of this Exhibit E.

J.C. Boyle Bypass Reach (J.C. Boyle Dam to Powerhouse)

The minimum flow of 100 cfs released from J.C. Boyle dam at all times will protect the high water quality conditions in the J.C. Boyle bypass reach and will maintain an enhanced condition over that which would result from higher minimum flow releases. The minimum flow of 100 cfs will allow the 225 cfs of cool, high-quality spring water that enters the reach to continue to dominate the composition of flow in the bypass reach.

The effects of instream flows on water quality conditions in the J.C. Boyle bypass reach were examined using the hydrodynamic and water quality models RMA-2 and RMA-11. Details on model methods and results are provided in the Water Resources FTR, Section 4.0.

Assumed instream flow releases from the dam to the bypass reach of 200, 400, 800, 1,000, 1,100, and 1,147 cfs were examined, along with the existing base case, which assumes a bypass instream flow release of 100 cfs. These releases represent step increases in bypass flows ranging from the current minimum flow release of 100 cfs to a hypothetical condition under which all flow is routed through the bypass reach and none is diverted to the J.C. Boyle powerhouse. Inflows to the bypass reach assumed a constant 225 cfs of spring flow accretion that enters within the upper 1 mile of the reach.

As a basis for this study, conditions for the week of July 19-26, 2000 (Julian days 201-207) were used. Hourly weather data can be particularly variable. To remove short-term anomalies (e.g., particular cloudiness or wind) and produce a representative daily weather record, weather parameters were averaged hourly over the week of July 19-26, 2000. Averages were compiled for each parameter and at each hour of the day to construct an average meteorological day for the week.

The quality of inflow to the model was specified hourly based on data collected at J.C. Boyle dam for the week of July 19-26, 2000. These values defined water quality of instream flow releases from the dam to the bypass reach. The water quality of spring inflow was assumed constant at a water temperature of 11^{o}C, dissolved oxygen of 9.7 mg/L (100 percent saturation), and 0.15 mg/L each for nitrate and phosphate.

To focus on how changes to bypass flows might affect water quality, hydrodynamics and water quality were simulated under relatively simple, repeating boundary conditions—i.e., daily cycles in peaking flows, meteorology, and inflow water quality were repeated over the course of the simulation. To eliminate the influence of initial conditions, simulations of both hydrodynamics and water quality extended over 5 simulated days. By inspection, initial conditions are "washed out" within 24 hours, so results are compared on the 4th day of simulation.

Results for flow, temperature, and dissolved oxygen are shown in Figure E3.8-1 for the bypass reach just above the J.C. Boyle powerhouse. Results indicate that, as bypass release flows are incrementally increased up to 800 cfs, water temperatures in the bypass reach are incrementally warmed, dissolved oxygen decreased, and ammonia increased (figures for other nutrients are shown in the Water Resources FTR, Section 4.0). At bypass release flows greater than 800 cfs, incremental changes are less pronounced. The reductions in water quality as bypass release flows are incrementally increased reflect the incrementally lesser proportions of high-quality water from spring inputs and higher proportions of lesser quality water released at, or diverted from, J.C. Boyle dam.

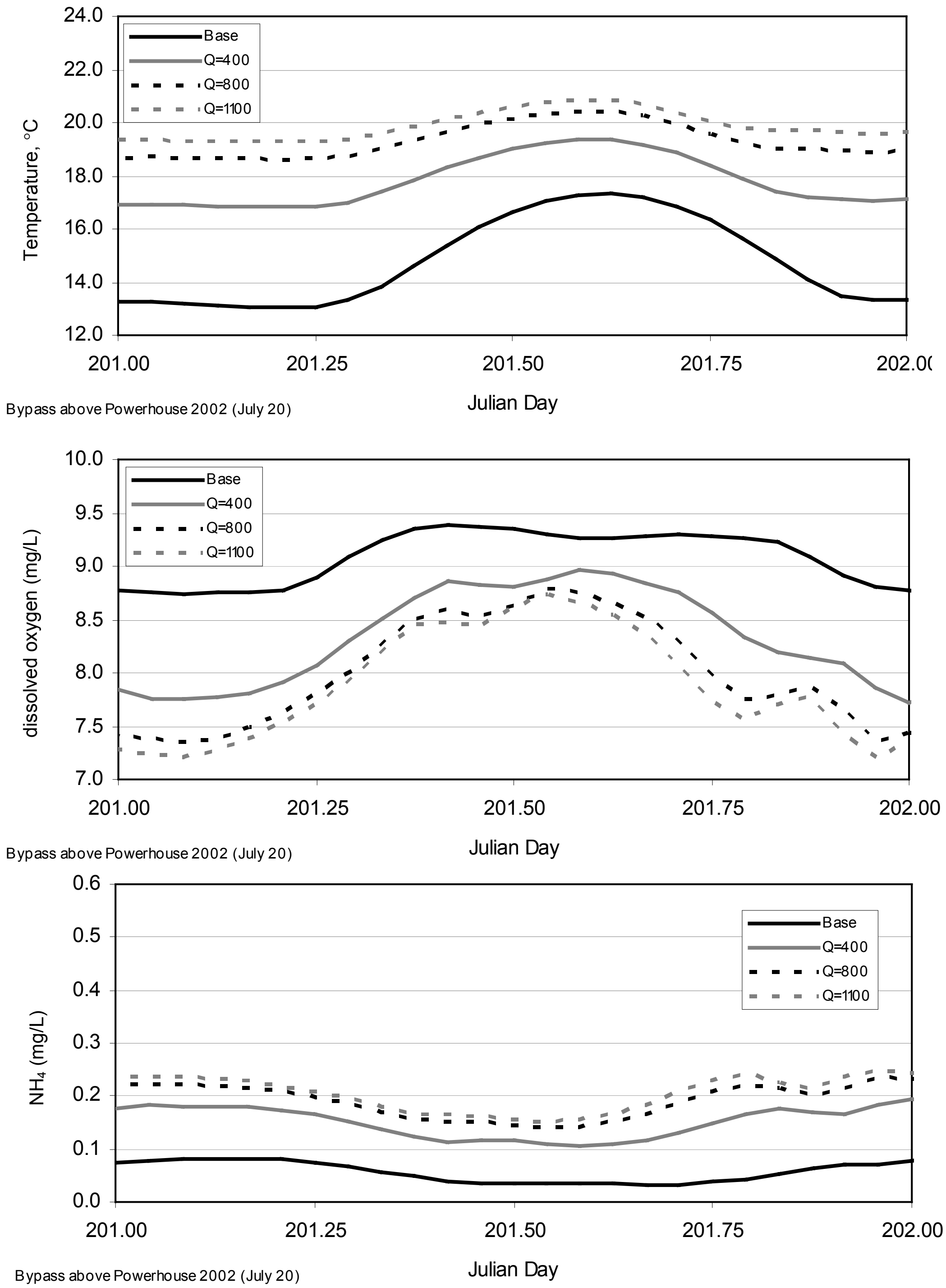


Figure E3.8-1. Model simulation results for various instream flow releases from J.C. Boyle dam to the J.C. Boyle bypass reach. Results are shown for water temperature (top), dissolved oxygen (middle), and ammonia (bottom).

The water quality modeling indicates that as bypass flows increase above the present operational level of 100 cfs the water quality benefits of the significant groundwater accretions in this reach are progressively reduced. At 800 cfs, the higher water quality benefits are reduced to only the immediate vicinity where spring accretion to the reach occurs. Retaining a release from J.C. Boyle dam of 100 cfs retains a region of high water quality throughout the J.C. Boyle bypass reach.

J.C. Boyle Peaking Reach (J.C. Boyle Powerhouse to Copco Reservoir)

Water quality monitoring has shown that operating J.C. Boyle dam in a steady-flow state results in an increase in the daily average temperature in the J.C. Boyle bypass reach. In July 2002, steady-flow conditions were maintained in the peaking reach as a result of maintenance at J.C. Boyle dam. Based on data provided to PacifiCorp by BLM, the daily minimum water temperature increased 2°C and the daily average water temperature increased nearly 1°C for the first 7 days of steady flow, compared to the previous 7 days of peaking flow, even though the daily minimum air temperature and daily average air temperature decreased by 1.5°C and 0.9°C, respectively, during the same period. However, an increased minimum flow level and adjustments in peaking operations proposed in the J.C. Boyle peaking reach will improve water quality conditions in the peaking reach, including decreasing the reach's unproductive varial zone.

The effects of instream flows on water quality conditions in the J.C. Boyle peaking reach were examined using the hydrodynamic and water quality models RMA-2 and RMA-11. Details on model methods and results are provided in the Water Resources FTR, Section 4.0. The basic modeling approach was the same as that described above for the J.C. Boyle bypass reach analysis. It is based on assumed instream flow releases from J.C. Boyle dam to the bypass reach of 200, 400, 800, 1,000, 1,100, and 1,147 cfs, along with the existing base case, which assumes a bypass instream flow release of 100 cfs. These releases represent step increases in bypass flows ranging from the current minimum flow release of 100 cfs with the balance of flows released to the peaking reach through the J.C. Boyle powerhouse, to a hypothetical condition under which all flow was routed through the bypass reach and none was diverted to the powerhouse.

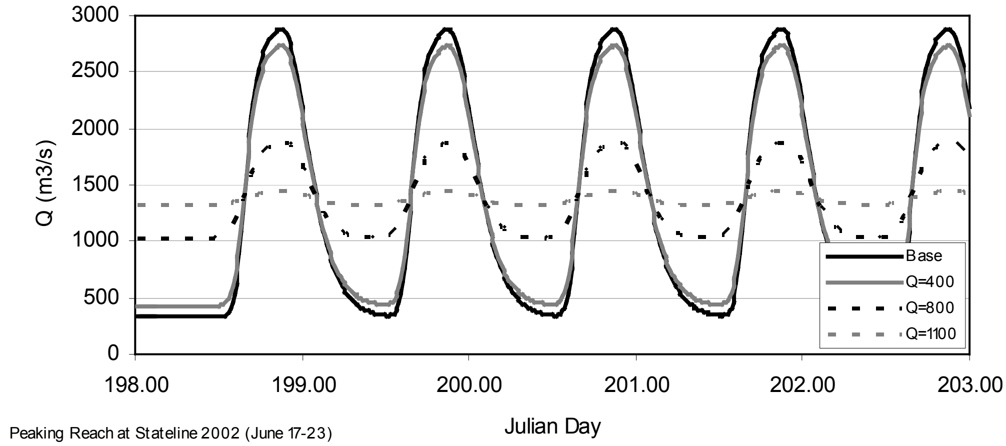
For each bypass instream flow scenario, the total daily flow in the peaking reach was calculated as the difference between total daily flow and total bypass flow. Hourly peaking flows for each scenario were calculated as the quotient of the total daily flow in the peaking reach and the fraction of total flow observed for each hour on July 19, 2000. The flow regimes thus defined all had the same total daily flow while flows through the powerhouse changed proportionally with changes in bypass flow. Scenarios were defined for bypass flows of 200, 400, 800, 1,000, 1,100, and 1,147 cfs. The last in this list of scenarios represents the condition under which all flow, except the assumed powerhouse minimum, is released to the bypass reach. Results for flow are shown in Figure E3.8-2 for the peaking reach at Stateline (RM 209) and just above Copco reservoir (RM 204). The flow results are shown for multiple days to illustrate that the same dynamic conditions were used for multiple days during the simulations.

Results of model simulations of water temperature, dissolved oxygen, and ammonia in the peaking reach are shown in Figures E3.8-3 through E3.8-5 (see Section 4.0 of the Water Resources FTR for results of other nutrients). The model indicates that water quality in the peaking reach is enhanced with an instream flow release of 200 cfs (as proposed by PacifiCorp) compared to the base case instream flow release of 100 cfs. However, the model also shows that water quality in the peaking reach is not appreciably different across instream flow releases less than about 800 cfs. When less than 800 cfs is released to the bypass reach, two factors dominate water quality conditions in the peaking reach:

1. Spring flow of water quality markedly different (higher quality) than J.C. Boyle releases to the bypass reach in sufficient quantity clearly affect conditions above the powerhouse tailrace.
2. The peaking nature of hydropower operations results in distinct periods of increased base flow, and periods when base flow is solely derived from the bypass reach.

At night when the powerhouse is off line, relatively high quality water from the bypass reach flows downstream. These conditions are observed at Stateline in the early morning hours. However, soon thereafter the peaking flows arrive at Stateline, consisting of J.C. Boyle bypass flows and J.C. Boyle reservoir waters of lesser quality. When these flows arrive, a change in water quality is observed (see results for ammonia). When releases to the bypass reach exceed 800 to 1,000 cfs, the aforementioned two processes play an increasingly minor role:

- Spring flow influence (dilution) is reduced because this component is making up a smaller fraction of the base flow, resulting in water of a less distinct quality leaving the bypass reach (i.e., water quality of flows leaving the bypass is more similar to powerhouse releases).
- The hydropower operations are greatly moderated, resulting in smaller variations in base flow at downstream locations.



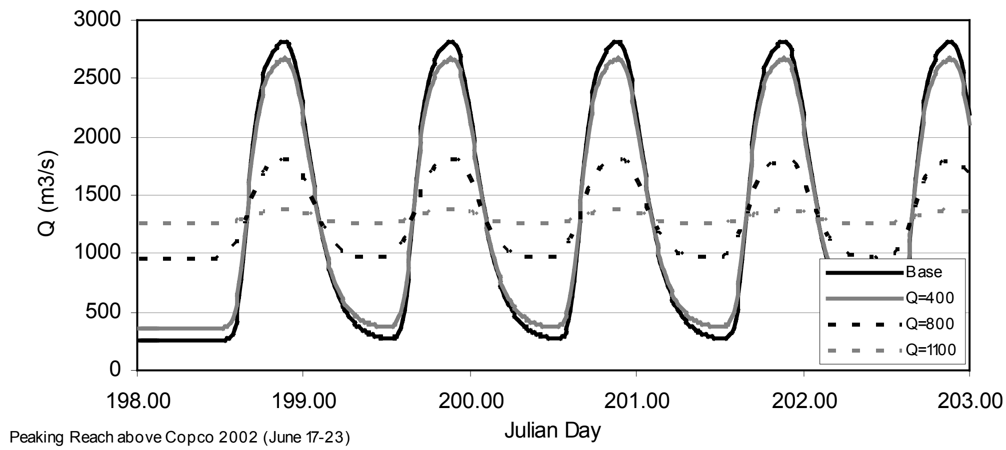
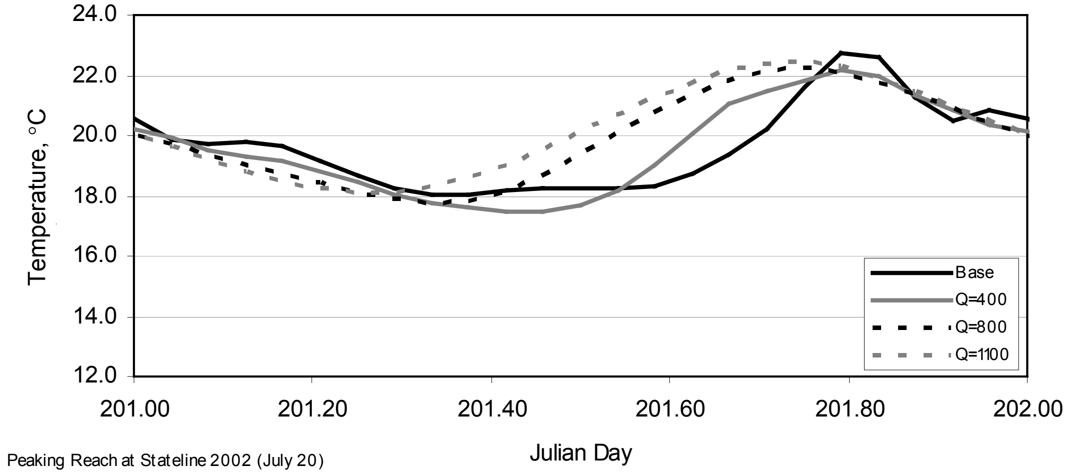


Figure E3.8-2. Model simulation results for flow in the J.C. Boyle peaking reach assuming various instream flow releases from J.C. Boyle dam to the J.C. Boyle bypass reach. Results are shown for Stateline at RM 209 (top), and just above Copco reservoir at RM 204 (bottom).



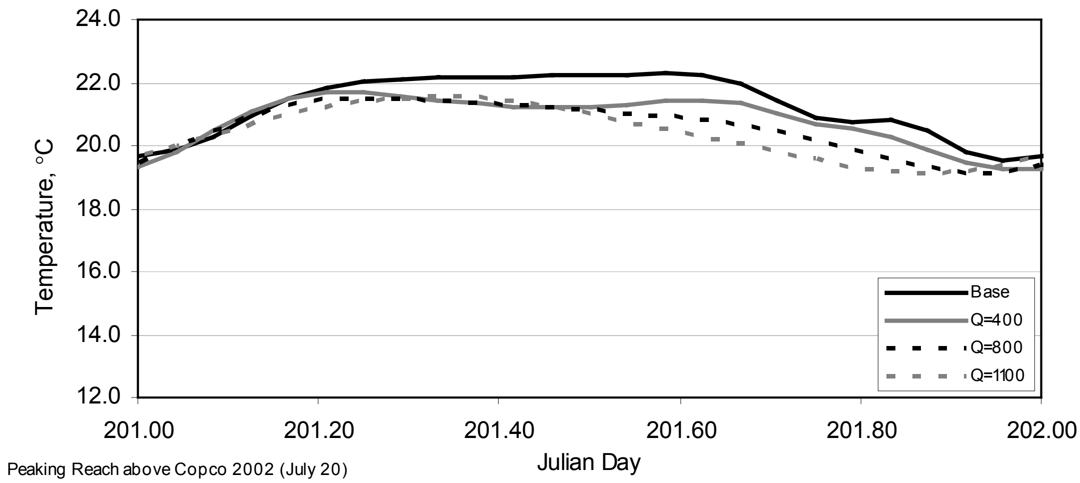
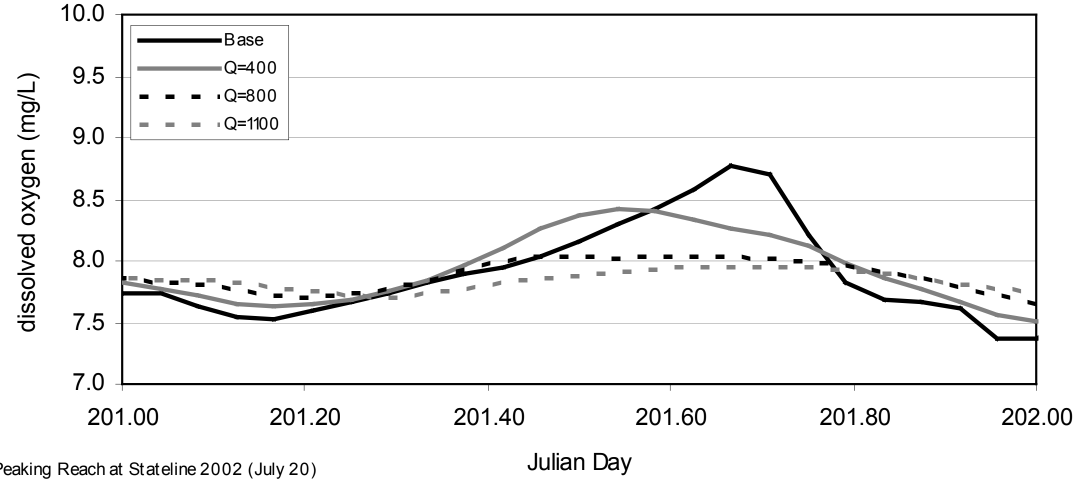
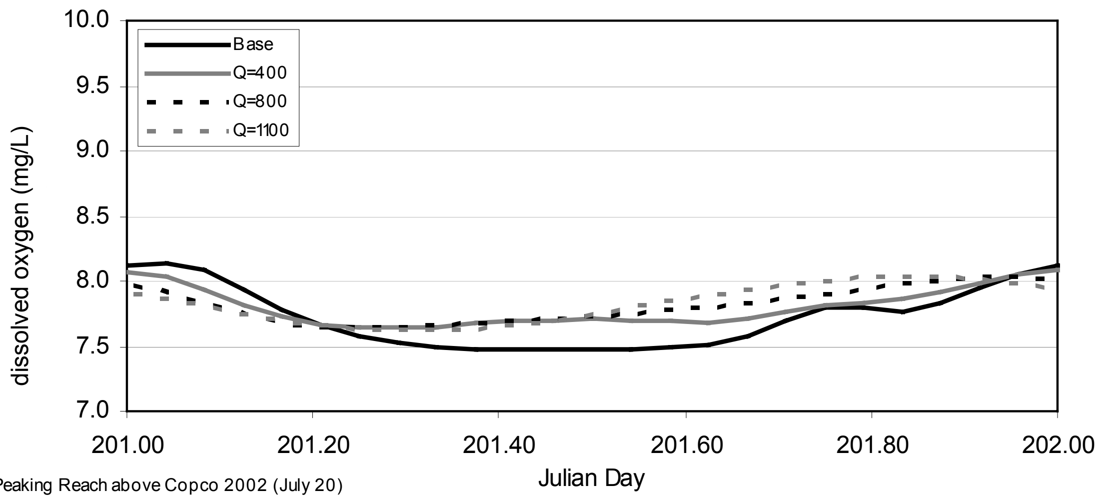


Figure E3.8-3. Model simulation results for water temperature in the J.C. Boyle peaking reach assuming various instream flow releases from J.C. Boyle dam to the J.C. Boyle bypass reach. Results are shown for Stateline at RM 209 (top), and just above Copco reservoir at RM 204 (bottom).

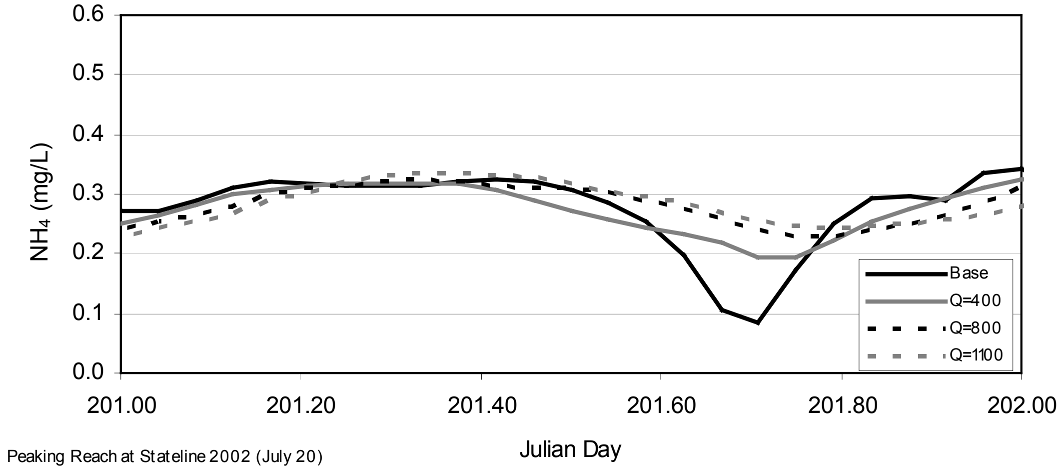


Peaking Reach at Stateline 2002 (July 20)



Peaking Reach above Copco 2002 (July 20)

Figure E3.8-4. Model simulation results for dissolved oxygen in the J.C. Boyle peaking reach assuming various instream flow releases from J.C. Boyle dam to the J.C. Boyle bypass reach. Results are shown for Stateline at RM 209 (top), and just above Copco reservoir at RM 204 (bottom).



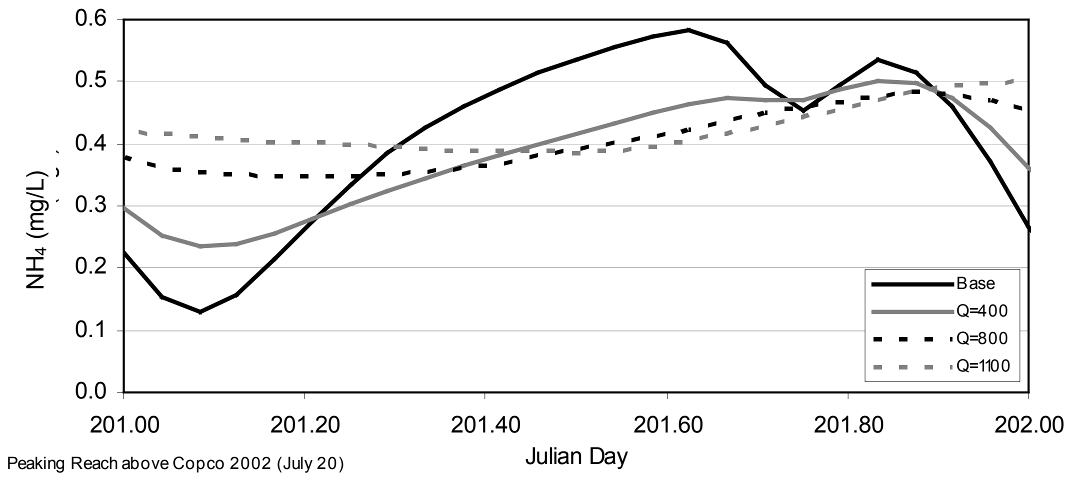


Figure E3.8-5. Model simulation results for ammonia in the J.C. Boyle peaking reach assuming various instream flow releases from J.C. Boyle dam to the J.C. Boyle bypass reach. Results are shown for Stateline at RM 209 (top), and just above Copco reservoir at RM 204 (bottom).

In addition to enhancing water quality, the proposed 200-cfs instream flow release will reduce the amount of unproductive varial zone[31] in the peaking reach. This reduction will increase the production of macroinvertebrates along the portion of the channel within the current varial zone. A more detailed description of the effects of flow measures on the varial zone is provided in section E4.8 of this Exhibit E.

Copco No. 2 Bypass Reach (Copco No. 2 Dam to Powerhouse)

A minimum flow of 10 cfs released from Copco No. 2 dam is similar to the minimum flow currently released. As a result, water quality conditions in the Copco No. 2 bypass reach are

31 The varial zone is the margin area along both sides of the river channel that is alternately watered and dewatered by daily flow fluctuations during peaking operations.

expected to remain at current levels. The bypass reach is short (1.4 miles) and consists of a high gradient, confined channel. As such, water quality in the reach is dominated by the quality of water released to it from Copco reservoir (via the small Copco No. 2 reservoir). Because of the short, high gradient nature of the channel, water transit time is short (about 3 hours or less). As a result, little change is expected to occur in water quality conditions released from Copco reservoir.

Klamath River Downstream of Iron Gate Dam

Iron Gate dam is, and will continue to be, operated in a modified run-of-river mode under the schedule for instream flow releases at Iron Gate dam dictated by USBR’s Klamath Irrigation Project Operations Plans (consistent with BOs issued by USFWS and NOAA-Fisheries). Any additional increases in discharges from Iron Gate dam would require additional flow from upstream of the Project.

This measure will preserve current conditions and, in combination with water temperature management or oxygenation measures (described below), will protect or enhance water quality conditions in the river below Iron Gate dam. The effectiveness of these combined measures is described below in sections on water temperature management and hypolimnetic oxygenation measures.

Fall Creek

A minimum flow of 5 cfs into the Fall Creek bypass reach and a minimum flow of 15 cfs downstream of the bypass confluence are primarily intended to enhance usable fish habitat (as described in section E4.8 of this Exhibit E). Even under the lower minimum flow currently released, water quality in Fall Creek is spring-flow dominated and considered excellent. The higher proposed minimum flow release will protect this high quality water.

Spring Creek

A specific minimum flow release to the Spring Creek bypass reach (provided at the Spring Creek diversion to Fall Creek) has not yet been determined; it will be developed in consultation with appropriate federal and state agencies. It is expected that, upon completion of studies and consultation with appropriate agencies, a minimum instream flow will be identified that protects water quality.

E3.8.3 Iron Gate Reservoir Low-level Withdrawal for Downstream Water Temperature Management

E3.8.3.1 Potential Measure

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

A potential measure being considered by PacifiCorp is implementation of a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some cooling of the Klamath River below the Project area. The low-level release would likely require retrofitting an existing low-level outlet at Iron Gate dam to permit controlled release of water from the bottom of Iron Gate reservoir and to release that water in a manner that would provide the greatest benefit to temperature conditions in the Klamath River.

Although hypolimnetic cool water storage is available in Iron Gate reservoir, the volume of this cool water is limited. As a result, the potential benefit from releases of this cool water for downstream temperature reduction is likewise limited and may not be practicable. Before committing to this measure, PacifiCorp will further consult with CSWRCB during the CWA Section 401 water quality certification process for the Project (described in section E3.4).

E3.8.3.2 Associated Water Quality Protection or Enhancement

To investigate the selective withdrawal for temperature management below Iron Gate dam, a number of scenarios were simulated using two different numerical models of the reservoir. Preliminary modeling was done using the U.S. Army Corps of Engineers Water Quality River-Reservoir System model to screen potential selective withdrawal outlet configurations. Using the results from the WQRRS screening simulations, selected scenarios were chosen for more detailed simulation with the CE-QUAL-W2 model. Use of both models allowed PacifiCorp to explore a greater range of potential configurations and operations. Details on model methods and results are provided in the Water Resources FTR, Section 4.0.

WQRRS is a one-dimensional model that represents the reservoir as a vertically segmented set of horizontally mixed layers. The WQRRS model of Iron Gate reservoir executes quickly and provides a good general view of water temperature response to reservoir operation. Using this model, 14 different release schedules were simulated and the impacts on outflow temperatures were compared.

CE-QUAL-W2 is a two-dimensional model and represents the reservoir as a set of laterally averaged, longitudinally and vertically distinct mixed boxes. Because of the greater detail and longer time span of this model, CE-QUAL-W2 simulation times are much longer than those of WQRRS for comparable scenarios. Because of its detail, CE-QUAL-W2 is considered the more definitive of the two models for this study and was used in the final evaluation of selective withdrawal scenarios.

In both models, releases were simulated from a combination of seven distinct intake locations in the reservoir; however, not all locations were used in any one scenario. These locations ranged from the bottom layer of the reservoir (at elevation 2,175 feet) to the spillway (elevation 2,328 feet. In the CE-QUAL-W2 simulations, spillway releases varied on a daily basis over the year and were the same under each simulation scenario. Table E3.8- lists the various release intake locations.

Table E3.8-1. Locations of simulated selective withdrawal release points for Iron Gate reservoir.

Release Intake Location	Elevation (above sea level)		Depth*
	(m)	(ft)	(ft)
Existing Dam Spillway	709.57	2328	0
Existing Upper Fish Hatchery Intake	704.10	2310	18
Existing Powerhouse Intake	700.74	2299	29
Assumed New Intake No. 1	694.00	2277	51
Existing Lower Fish Hatchery Intake	687.03	2254	74
Assumed New Intake No. 4	679.70	2230	98
Assumed New Intake No. 2	675.00	2215	113
Assumed New Intake No. 3	662.94	2175	153
Reservoir Bottom	661.38	2170	158

* Depth from spillway invert. Actual operating depths are generally less under nonspill conditions

In screening simulations with WQRRS, the base case, representing existing conditions, assumed that all outflow is released from the existing powerhouse intake ("Powerhouse") elevation, except for a constant daily 40-cfs release from the existing lower fish hatchery water supply intake ("lower fish"). No spills were assumed during the period of analysis.

A dozen different selective withdrawal scenarios were simulated, representing different release configurations. These were compared to the base case and each other to determine the scenario most likely to provide measurable benefit. In these scenarios, the assumed release locations and amounts were changed as many as five times during the simulation period. No spills were assumed, and releases at the existing lower fish hatchery water supply intake were always a constant daily value of either zero or 40 cfs.

As an example, a typical release scenario (Run 1) is illustrated in Figure E3.8-6. The figure shows a constant small release of 40 cfs from the "lower fish" release intake elevation throughout a simulation period that extends from mid-May to the end of December. During the simulation, all other outflow is released from the powerhouse until mid-August, when release from an assumed new intake (No. 2) at elevation 2,215 feet begins to ramp up and the powerhouse release begins to ramp down until October. From October to the end of December, release conditions remain the same, with 40 cfs released at the lower fish hatchery intake elevation and the remainder of outflow split evenly between new intake No. 2 and the powerhouse.

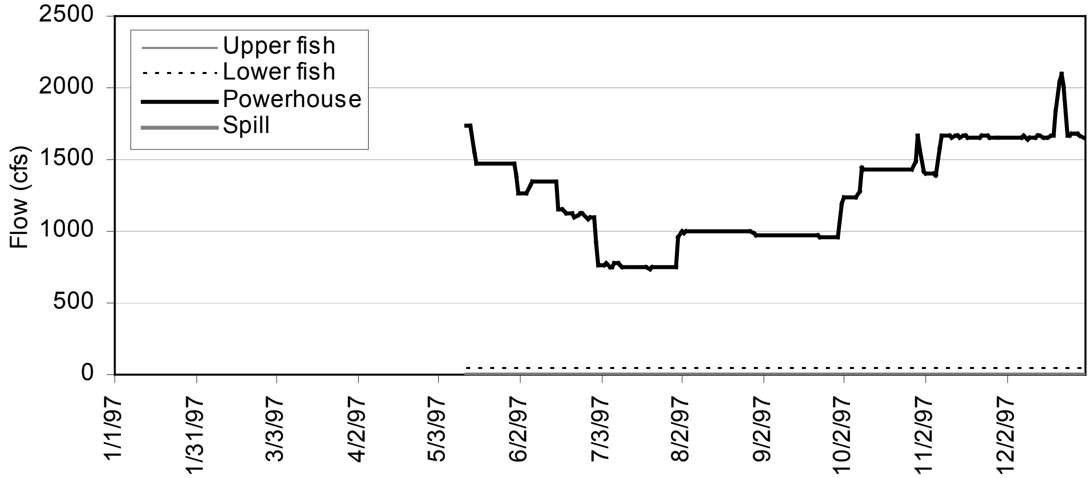


Figure E3.8-6. WQRRS simulated release flows for Run 1.

In general, results of the screening simulations with WQRRS show that the release of cold bottom water early in the season (before the end of August) depletes the cold-water reserve in the hypolimnion relatively quickly and provides benefit for only a short period of time (on the order of days or weeks) before the reservoir is destratified by the withdrawals and warm upper water is mixed downward. Using intermediate release locations does not help appreciably because the warm upper water mixes down quickly as water is released from lower layers.

WQRRS simulations indicated that two of the scenarios (Runs 6 and 8) were most effective. These scenarios assume a strategy of slowly increasing releases from the bottom of the reservoir late in the summer to utilize the reservoir's cold-water hypolimnion most efficiently. Run 6 has the advantage of being simpler, with only two (instead of three) release locations. Under both scenarios, no water is released at the lower fish hatchery elevation, which translates to no fish hatchery releases. Run 6 specifies that releases begin to shift from the powerhouse location to an assumed new release intake (No. 3) at the bottom of the reservoir in late August. Run 6 further specifies that, by the end of October, all water is released from the release intake at the bottom of the reservoir. Run 8 is similar to Run 6 but represents a more complex release schedule employing a release located between the existing lower fish hatchery water supply intake and an assumed new release intake at the bottom of the reservoir (No. 2).

Based on findings from simulations with WQRRS, the Run 6 and Run 8 selective withdrawal strategies, along with the base case, were further tested with the more detailed CE-QUAL-W2 model using year 2000 conditions. Results of CE-QUAL-W2 simulations are similar to the WQRRS results, showing that the selective withdrawal scenarios can reduce outflow temperatures from early September to late October. However, the CE-QUAL-W2 simulations show a lesser reduction of outflow temperature being sustained past late October. This difference may be due primarily to the two-dimensional representation of the reservoir by CE-QUAL-W2 (compared with one-dimensional representation by WQRRS).

Run 6 resulted in the lowest release temperatures for the greatest sustained period (late August to mid-October). Release temperatures resulting from the scenario of Run 6 simulated by

CE-QUAL-W2 are shown in Figure E3.8-7. These release temperatures are up to about 2°C cooler than the base case release temperatures. The release schedule for the year for Run 6 is shown in Figure E3.8-8.

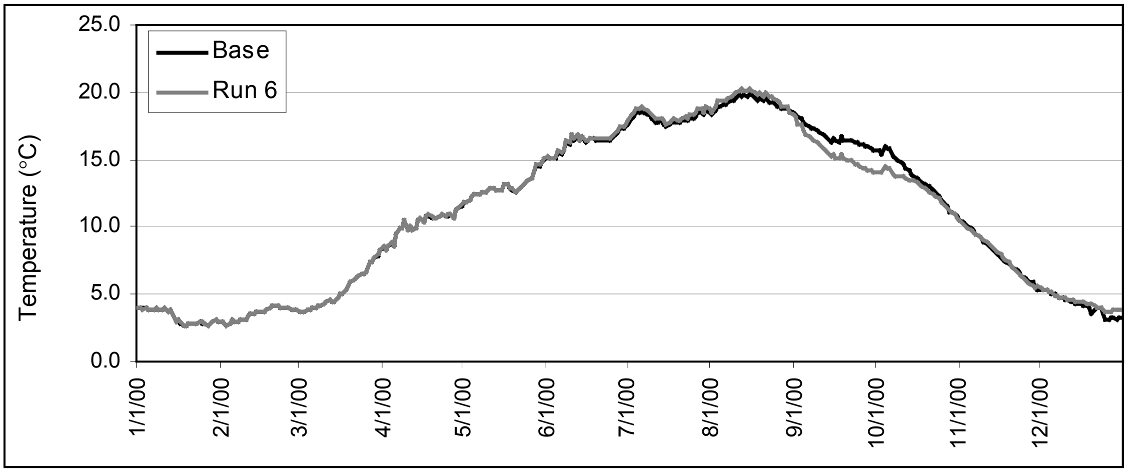


Figure E3.8-7. CE-QUAL-W2 simulated mean daily water temperature for Iron Gate reservoir releases for Run 6 (Jan. 1-Dec. 31, 2000).

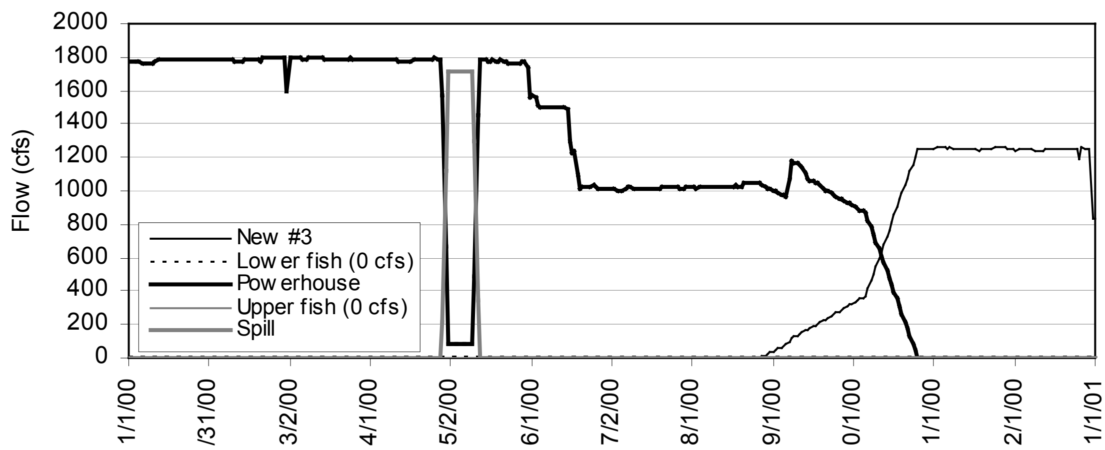


Figure E3.8-8. CE-QUAL-W2 simulated release flows for Run 6 (Jan. 1-Dec. 31, 2000).

The effects of changes in selective withdrawal release temperatures in the downstream Klamath River reach from Iron Gate dam to Turwar were examined using the RMA models. Results on July 14 showed no significant difference among the alternatives. However, results from September 30, during the selective withdrawal operations, indicated modest effects in downstream reaches. Temperature differences from selective withdrawal observed (Figure E3.8-9) in the vicinity of Iron Gate dam decline with downstream distance from Iron Gate dam. At the dam (RM 190), differences of Run 6 versus the baseline are about 2°C or less. By Seiad Valley (RM 129), differences are less than 0.5°C.

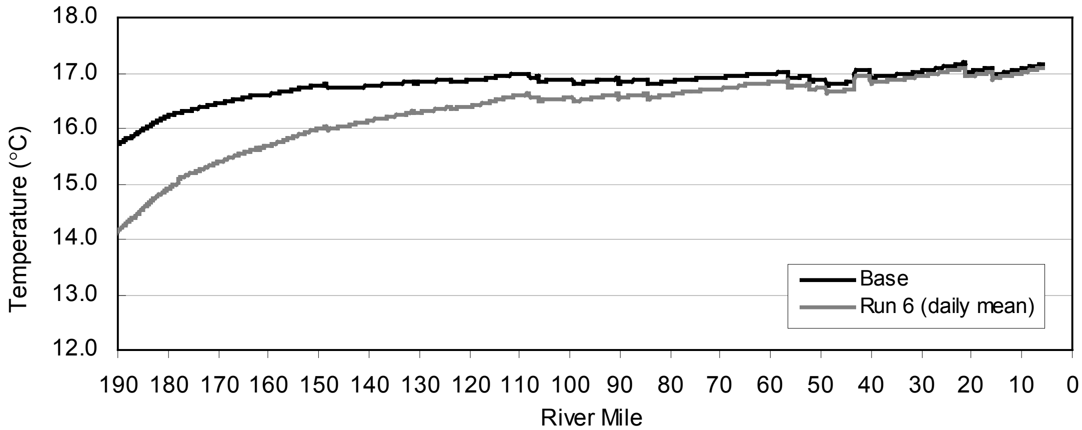


Figure E3.8-9. RMA-11 simulated longitudinal profile of mean daily water temperature for September 30, 2000, under selective withdrawal conditions for Run 6.

Results of the model simulation suggest that low-level withdrawal can result in decreases in outflow temperatures, but they would be modest and temporary. Release of cold bottom water early in the season (i.e., before the end of August) depletes the cold-water reserve in the hypolimnion quickly and provides benefit for only a short period of time (at most, about 6 weeks) before the reservoir is destratified by the withdrawals and warm upper water is mixed downward. Using intermediate release locations does not help appreciably because the warm upper water mixes downward as water is released from lower elevations. Because the cold water supplies available in Iron Gate reservoir are relic winter waters, when the supply is exhausted there are no additional sources until the subsequent winter replenishes the cold water pool.

On the basis of this analysis, PacifiCorp concludes that low-level withdrawal of cool water storage in Iron Gate reservoir for temperature management downstream of Iron Gate dam is limited and may not be practicable. Before committing to this measure, PacifiCorp will further consult with ODEQ and CSWRCB during the Section 401 water quality certification process for the Project (described in section E3.4).

E3.8.4 Iron Gate Reservoir Oxygenation or Re-aeration System

E3.8.4.1 Proposed Measure

As a consequence of the normal temperature stratification of Iron Gate reservoir and the biological processes occurring in the reservoir, the hypolimnetic water is deficient in oxygen by late summer and might be detrimental to aquatic life in the river below the Project if released. In order to prevent any adverse effects that might occur as a result of the oxygen-deficient condition of the released water, PacifiCorp proposes to install an oxygenation or re-aeration system. Two alternative systems are being considered: (1) a system to oxygenate the hypolimnion of Iron Gate reservoir using hypolimnetic oxygen diffuser technology; or (2) a system to oxygenate or reaerate low-level (hypolimnetic) waters released from the dam using a re-aeration valve or oxygen injection. Before selecting the specific system, PacifiCorp will seek further consultation with CSWRCB during the Section 401 water quality certification process for the Project (described in section E3.4).

E3.8.4.2 Associated Water Quality Protection or Enhancement

Hypolimnetic aeration and oxygenation has been used around the world as a means to reduce the adverse effects of anoxia in the hypolimnion of lakes and reservoirs (Buetal and Horne, 1999). Several methods have been used, but the most effective have been linear diffusion lines and the Speece cone. Although effective, these systems have high costs. For example, oxygenation systems require transport or on-site generation and on-site storage of oxygen. PacifiCorp is currently evaluating aeration and oxygenation methodologies to determine the most cost-effective means to achieve the desired effect.

CE-QUAL-W2 was used to assess the potential impacts of hypolimnetic oxygenation combined with low-level withdrawal on water quality in Iron Gate reservoir and in the Klamath River below Iron Gate dam (see the Water Resource FTR, Section 4.0). Constituents modeled in the CE-QUAL-W2 simulations included water temperature, total dissolved solids, phosphate, ammonia, nitrate, labile and refractive dissolved material, labile and refractive particulate material, carbonaceous BOD, algae, dissolved oxygen, total inorganic carbon, and alkalinity. To assess the potential effects of hypolimnetic oxygenation, simulations with a minimum dissolved oxygen set to 5 mg/L were completed to estimate the impacts on outlet dissolved oxygen concentrations, as well as the response of other water quality constituents.

The results of the model indicate that hypolimnetic oxygenation would increase dissolved oxygen in the discharge over base case conditions during mid-July through October (Figure E3.8-10). The Run 6 scenario (previously defined in section E3.8.4), which includes a minimum 5.0 mg/L in-reservoir dissolved oxygen (labeled “Run6-minDO=5” in Figure E3.8-10) increases dissolved oxygen from between 1 to 2 mg/L over the base case (labeled “Base” in Figure E3.8-10), with no values less than 5 mg/L. Also, as a result of increasing dissolved oxygen during mid-July through October, the model predicts decreases in ammonia, labile dissolved organic matter, and orthophosphate in the hypolimnion, and nitrate in the outflow.

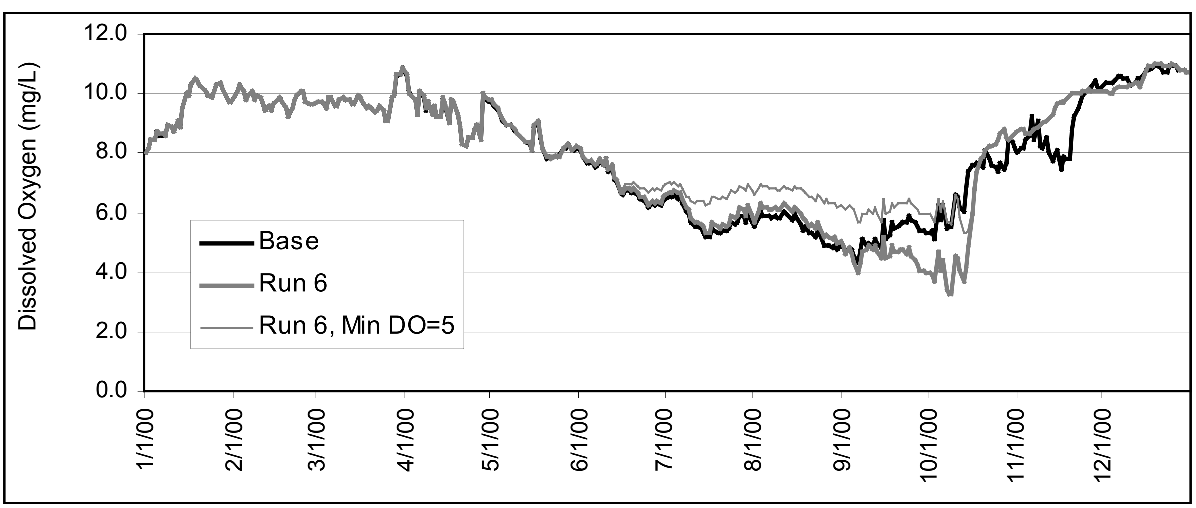


Figure E3.8-10. CE-QUAL-W2 simulated mean daily dissolved oxygen for Iron Gate reservoir release (Jan. 1-Dec. 31, 2000).

The RMA models were used to determine the effects of the proposed hypolimnetic aeration/ oxygenation on the Klamath River from Iron Gate dam to the mouth. The longitudinal model run for the Klamath River using data and model results for September 30, 2000, indicated that modest dissolved oxygen improvements would occur. However, the distance downstream at which operations with this measure in place showed no appreciable difference from the base case condition is only about 20 miles (Figure E3.8-11).

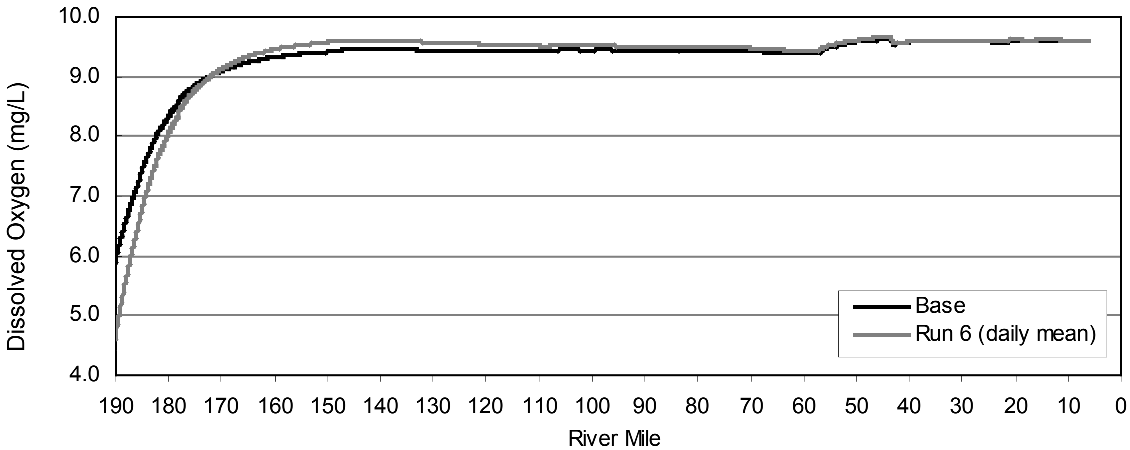


Figure E3.8-11. RMA-11 simulated longitudinal profile of mean daily dissolved oxygen for September 30, 2000, under selective withdrawal conditions for Run 6.

E3.8.5 Maintenance Scheduling

E3.8.5.1 Proposed Measure

PacifiCorp will consult with appropriate agencies on the annual scheduled outages for Project maintenance events where flows in Project reaches are required to be outside the normal operations.

E3.8.5.2 Associated Water Quality Protection or Enhancement

Consultation and coordination with agencies will ensure that times are selected to complete maintenance activities that do not affect sensitive life stages of fish or water quality.

E3.8.6 Schedule and Costs for Implementation of Proposed Measures.

Implementation of the proposed measures will begin upon issuance of the new license. Costs of the measures are summarized in Table E3.8-2.

Table E3.8-2. Costs of proposed measures for water use and quality.

Proposed Measure	Capital Costs	O&M Costs
Instream Flows and Ramping Rates	See section E4.8 for these costs	See section E4.8 for these costs
Iron Gate Oxygenation/Re-aeration System	$950,000	$5,400,000
Maintenance Scheduling	None	$1,000

E3.9 CONTINUING IMPACT ON WATER USE AND QUALITY

During the new license period, PacifiCorp will continue to operate its currently licensed facilities, except for the East Side and West Site Developments at Link River, which will be decommissioned, and Keno dam, which will not be part of the Project. Operations will continue at the J.C. Boyle development, including load following (peaking) operations. Diversion of flows up to 2,850 cfs from the J.C. Boyle bypass reach (except for a minimum instream flow release of 100 cfs from J.C. Boyle dam) will continue to allow 225 cfs of high-quality spring inflow to dominate and enhance water quality conditions in the reach. Peaking operations at the J.C. Boyle powerhouse will continue to occur when flows are less than 2,850 cfs, causing daily flow fluctuations in the peaking reach. These flow fluctuations will continue to cause the presence of the relatively less productive varial zone along the margin of the Klamath River's channel, and cause a larger daily range of water temperatures than would occur without the Project. However, implementation of instream flow and ramping rate enhancement measures as proposed will reduce the magnitude of these flow fluctuations (described in E4.0, Fish Resources, of this Exhibit E).

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

The existing Project reservoirs included in this new Project license application—J.C. Boyle, Copco, and Iron Gate—will have continuing effects on water quality. These reservoirs differ markedly from the river reaches in their water quality character, mainly because of the longer hydraulic residence time in the reservoirs. These reservoirs are more effective than the river in retaining organic matter, especially particulate forms, and nutrients delivered from Upper Klamath Lake and the Klamath Irrigation Project. Retention of organic matter and nutrients in the reservoirs results in periodic seasonal blooms of planktonic algae and contributes to low dissolved oxygen below the thermocline. This results in a net decrease in organic matter and nutrients that would otherwise continue downstream and contribute to increased algae growth in the Lower Klamath River.

J.C. Boyle reservoir is relatively small, with short residence time and limited, weak thermal stratification. Copco and Iron Gate reservoirs are larger, deeper reservoirs with water quality characteristics that include stable seasonal thermal stratification. As a consequence of thermal stratification in Iron Gate reservoir and the biological processes occurring in the reservoir, the hypolimnetic water is deficient in oxygen by early summer, which might be detrimental to aquatic life in the river if released below the Iron Gate dam. PacifiCorp proposes to install an oxygenation or aeration system (described in E3.8 of this document) to prevent any adverse effects that might occur as a result of the oxygen-deficient condition of the released water. The specific system to be installed will be determined based on further consultation with CSWRCB during the CWA Section 401 water quality certification process for the Project. Another potential measure being considered by PacifiCorp is implementation of a low-level release of cooler hypolimnetic water from Iron Gate reservoir during summer to provide some cooling of the Klamath River below Iron Gate dam (described in section E3.8). However, the volume of this cool water is limited. Therefore, the potential benefit from releases of this cool water for downstream temperature reduction is likewise limited. Before determining whether to propose this measure, PacifiCorp will consult further with CSWRCB during the CWA Section 401 water quality certification process for the Project.

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

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

E3.10 BASINWIDE WATER USE OF HEADWATERS AGREEMENTS OR COMMISSION ORDERS THAT BENEFIT THE PROJECT

There are no headwater agreements associated with the current license. The 1956 contract between USBR and PacifiCorp provided a Project benefit through regulation of Upper Klamath Lake. However, that benefit has been lost due to listing of ESA species (see Exhibit B for additional information on the 1956 contract and the effects of ESA listings on Project operations).

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