3.0 ENVIRONMENTAL CONSEQUENCES

In this section, we first describe the general environmental setting in the project vicinity and any environmental resources that could be cumulatively affected by relicensing the Klamath Hydroelectric Project facilities. Then we address each affected environmental resource. For each resource, we first describe the affected environment—the existing condition, and the baseline against which to measure the effects of the proposed project and any alternative actions—and then the environmental effects of the proposed project, including proposed enhancement measures. Unless otherwise stated, the source of our information is the license application for the project (PacifiCorp, 2004a).

3.1 GENERAL DESCRIPTION OF THE KLAMATH RIVER BASIN

The Klamath River watershed begins in the northwestern-most extent of the Basin and Range physiographic province and is one of only three drainages originating in Oregon that cut across both the Cascade and Coastal ranges. It is also unique because of its large, north-south-striking headwater lake and wetland complex—the Klamath River Basin—located in south-central Oregon and northwestern California. The Klamath River Basin lies in the transition zone between the Modoc Plateau and Cascade Range physiographic provinces, with the Klamath River cutting west through the Klamath Mountain province and then the Coast Range province where it reaches the Pacific Ocean near Requa, California. The Klamath River passes through four distinct geologic provinces, each of which changes the character of the river's channel morphology and that of its tributary watersheds, varying the supply of inputs such as water, sediment, nutrients, and wood.

The upper Klamath Basin, within the Modoc Plateau province, is bounded on its west side by the eastern edge of the Cascades Range, with tributaries of Wood River draining the flanks of the Crater Lake area (see figure 1-1). To the east, the northwesterly trending fault-block mountains with intervening valleys are commonly interspersed with lakebed deposits, shield volcanoes, cinder cones, or lava flows. Shallow lakes (Upper Klamath, Lower Klamath, and Tule lakes) and marshes (Klamath Marsh) are prominent features of the Modoc Plateau, as are areas drained by Anglo-American immigrants. The land surrounding the lakes and the drained lake areas now serves as productive agricultural land. The high-elevation, semi-arid desert environment of the Modoc Plateau receives an average of about 15 inches of precipitation annually. With its porous volcanic geology and relatively moderate topography, runoff is slow, and there are relatively few streams compared to downstream provinces. Sediment yield also is low relative to provinces downstream.

The transition from the Modoc Plateau to the Cascade Range province is subtle; the Klamath River enters the Cascade Range province roughly in the area below Keno dam. The Shasta River is the major tributary to the Klamath River within the Cascade Range province (see figure 1-1). The headwaters of the Shasta River originate on the flanks of Mt. Shasta and the majority of its watershed is comprised of the expansive Shasta Valley (Crandell, 1989). The western side of the Shasta River and Cottonwood Creek watersheds marks the western boundary of this province. The portion of the Cascade Range province included in the Klamath River watershed is largely in the rain shadow of Mt. Shasta and the Klamath Mountains; precipitation is highly variable by elevation and location. Mass wasting and fluvial erosion are the main erosional processes within this province (Forest Service, 2005).

The Klamath Mountains province includes a complex of mountain ranges in southwest Oregon and northwest California, collectively called the Klamath Mountains; they include the Trinity Alps, Salmon Mountains, Marble Mountains, and Siskiyou Mountains. Large tributary watersheds to the Klamath River in this province include the Scott, Salmon, and Trinity rivers. Compared to all other areas of the Klamath River watershed, this province includes some of the steepest topography and tallest mountains; summits in the Trinity Alps exceed 9,000 feet in elevation. Gold-bearing deposits occur within this province, and the legacy effects of gold mining and dredging persist in some areas. Precipitation generally increases in proximity to the coast, so here soils are generally deeper than in

upstream provinces. Deep soils, steep slopes, and high precipitation make mass wasting and fluvial erosion the main geomorphic processes in this province, particularly in the middle to lower portions of the mid-Klamath River (i.e., the Salmon River watershed) (Forest Service, 2005; de La Fuente and Haessig, 1993). Because of this, sediment yields are relatively high compared to upstream areas of the Klamath River watershed.

The lowermost 40 miles of the Klamath River (from the town of Weitchpec to the Pacific Ocean) traverse the Coast Range province. The Coast Range province comprises three linear belts of rock separated by faults (most notably the San Andreas and also including thrust faults that are presently increasing the height of the range). The Klamath River watershed portion of the Coast Range province comprises Franciscan Complex rocks. These rocks are generally sandstones with smaller amounts of shale, chert, limestone, conglomerate, as well as serpentine and blueschist. Because of Coast Range faulting, the relatively young Franciscan rocks are still uplifting, encouraging steep hillslopes and relatively high erosion rates resulting in high sediment yields.

The Klamath River begins at the outlet of Upper Klamath Lake in Oregon at elevation 4,139 feet and flows southwest approximately 260 miles to the Pacific Ocean at Requa, California. Most of the inflow to the upper Klamath River Basin enters Upper Klamath Lake via the Sprague, Williamson, and Wood rivers. Upper Klamath Lake is a shallow, regulated natural lake, which serves as a storage reservoir for extensive, irrigated lands (approximately 250,000 acres) in the basin.

Temperatures in the project area range from below freezing during the winter to 38 degrees Celsius (°C) during the summer. The higher elevation, upstream part of the project area is generally cooler than the downstream Iron Gate and Copco areas. Average annual precipitation is 18.2 inches at Copco reservoir, although higher elevation areas in the surrounding mountains can receive more than 50 inches on average. Annual precipitation in Klamath Falls is 13.3 inches, and precipitation in the project area occurs primarily as rain, mostly during the fall and winter, with occasional afternoon thunderstorms occurring in the summer. During the winter, snow is common, particularly in the higher elevations (i.e., above the canyon rim and east to Klamath Falls).

Historically, annual precipitation patterns define distinct dry and wet cycles that are closely related to runoff on the river. 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. Gaged runoff and flow patterns on the river closely reflect these climatic cycles. General decreases in runoff and discharge during the last 20 years also coincide with a generally decreasing trend in precipitation amounts. The peak of the natural annual hydrograph in the area is dominated by spring snowmelt.

3.2 SCOPE OF THE CUMULATIVE EFFECTS ANALYSIS

According to the Council on Environmental Quality's regulations for implementing NEPA (50 CFR §1508.7), an action may cause cumulative effects on the environment if its effects overlap in space and/or time with the effects of other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

Based on information in the license application, agency comments, other filings related to the project, and preliminary staff analysis, we preliminarily identified the following resources that have the potential to be cumulatively affected by the continued operation of the Klamath Hydroelectric Project in combination with other activities in the Klamath River Basin: geomorphology, water quantity, water quality, anadromous fish, ESA-listed suckers, rainbow trout, and socioeconomic values.

The Klamath Hydroelectric Project is located on the Klamath River. Most of the project water comes from Upper Klamath Lake, part of Reclamation's Klamath Irrigation Project. The Klamath

Irrigation Project, which has been in existence since 1905, uses water from the Klamath and Lost rivers to supply agricultural water users in southern Oregon and northern California. A portion of the water diverted from Upper Klamath Lake and the Klamath River for irrigation purposes returns to the Klamath River, along with certain return flows from the Lost River, at Keno reservoir.

Since about 1992, Reclamation 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 ESA. To protect these fish, FWS required that water levels in Upper Klamath Lake be managed within specific elevation limits. In 1999, in response to ESA listing of Southern Oregon/Northern California Coasts coho salmon Evolutionarily Significant Unit (ESU), NMFS provided a BiOp and an associated Incidental Take Statement to Reclamation containing terms and conditions that require Reclamation to provide for specific instream flows at Iron Gate dam and PacifiCorp to operate the dam to release those specified instream flows and implement identified ramping rates. Reclamation now defines Klamath Irrigation Project operations through annual operations plans in consultation with NMFS and FWS. The plan specifies how Upper Klamath Lake elevation and discharge at Iron Gate dam are to be regulated based on hydrological conditions.

Reclamation has been engaged in a planning process since the mid-1990s to develop a long-term operating strategy for the Klamath Irrigation Project. It began preparation of its EIS in 1997, and this preparation is ongoing. Alternatives identified in the Reclamation EIS could affect the Klamath Hydroelectric Project. Pursuant to a requirement of the May 2002 NMFS BiOp for Klamath Irrigation Project operations, Reclamation is currently developing the Klamath River Conservation Implementation Plan (CIP). The CIP is a basinwide multi-interest initiative to address issues associated with endangered fish in the Klamath River Basin, and it will address protection, restoration, and enhancement of fisheries and other aquatic resources. This program could be relevant to our cumulative effects analysis for the Klamath Hydroelectric Project.

3.2.1 Geographic Scope

The geographic scope of the analysis defines the physical limits or boundaries of the proposed action's effects on the resources. Because the proposed action would affect the resources differently, the geographic scope for each resource may vary.

For geomorphology, water quantity, and water quality, we include Upper Klamath Lake, the area encompassed by the Lower Klamath Lake Wildlife Refuge (which includes Lower Klamath Lake); the Lost River diversion channel; the Lost River from the confluence of the Lost River diversion channel to Tule Lake; Tule Lake; the mainstem Klamath River to its confluence with the Pacific Ocean; and the Shasta, Trinity, Scott, and Salmon rivers (the four major tributaries to the Klamath River downstream of Iron Gate dam). We chose this geographic scope because project developments, major irrigation diversions (which occur at Upper Klamath Lake, Keno reservoir, and the Shasta and Trinity rivers) and returns (which occur at Keno reservoir), and land use practices have cumulatively affected geomorphology, water quantity, and water quality within and downstream of the project area, and these effects have been linked by some parties to aquatic habitat effects in the mainstem Klamath River.

For ESA-listed sucker species (the Lost River and shortnose suckers), our geographic scope of analysis includes Upper Klamath Lake, the area encompassed by the Lower Klamath Lake Wildlife Refuge, the Lost River diversion channel, the Lost River from the confluence of the Lost River diversion channel to Tule Lake, Tule Lake, and the mainstem of the Klamath River to Iron Gate dam. This area includes the lake and reservoir habitat that is suitable for these species as well as riverine migratory corridors between the lakes and reservoirs.

For rainbow trout, we include all habitat that was historically accessible to rainbow trout upstream of Iron Gate dam. This includes spawning, rearing, and adult habitat that is currently directly

influenced by project operations; fish passage facilities operated by PacifiCorp and Reclamation; and potentially accessible habitat upstream of Upper Klamath Lake.

For anadromous fish, we include the mainstem Klamath River and all habitat that was historically accessible upstream of the mouth of the river. We chose this geographic scope because project developments, irrigation diversions, and land use practices have cumulatively affected the condition of upstream historic habitats as well as the downstream mainstem river corridor that is currently used by anadromous fish. Anadromous fish that use mainstem tributaries downstream of Iron Gate dam for spawning and rearing habitat could be cumulatively affected by water quality and quantity in the mainstem of the river (which could block upstream adult movement or downstream juvenile movement), as well as the timing of fish released from or returning to the Iron Gate Hatchery (which could create crowding conditions and conflict with key habitat space limitations, such as thermal refugia). We also consider appropriate management plans for salmon fisheries including those relating to the Klamath Management Zone, which extends 200 miles offshore from Humbug Mountain, Oregon, to Horse Mountain (near Shelter Cove), California. We consider these plans because harvest (including commercial, tribal, and recreational) and escapement for Klamath stocks can affect the numbers of adult salmonids returning to the Klamath River Basin to spawn. We acknowledge that management measures for Klamath River fall Chinook salmon currently constrain fishing on other salmon stock, from central Oregon to central California. As mentioned above, Klamath Hydroelectric Project structures and operation can affect adult spawning and subsequent downstream migration of juvenile salmonids which, in turn, serve as the basis for future harvests.

For socioeconomic values, we include the same geographic area defined for anadromous fish in the previous paragraph. We also include the geographic area encompassed by the Klamath Irrigation Project, which includes about 240,000 acres of irrigable lands in southern Oregon and northern California, adjacent National Wildlife Refuges, and some other non-Klamath Irrigation Project lands that consumptively use upper Klamath River Basin water. We include the same geographic area defined for anadromous fish because numerous actions that can influence the abundance of anadromous fish stocks, including relicensing the Klamath Hydroelectric Project, influences the incomes of people who depend on that resource for both commercial (including tribal) and recreational purposes. We include the area encompassed by the Klamath Irrigation Project, as well as the additional water users, including the refuges, because they historically received reduced electrical rates and other benefits pursuant to a 1956 contract between the licensee of the Klamath Hydroelectric Project and Reclamation. This contract expired in April 2006, and the loss of financial benefits associated with this contract would influence the economic viability of those entities historically receiving them. This overlapping action represents a potential cumulative socioeconomic effect that we consider in this EIS.

3.2.2 Temporal Scope

The temporal scope of our cumulative effects analysis in this EIS includes past, present, and future actions and their possible cumulative effects on each resource. Based on the license term, the temporal scope looks 30 to 50 years into the future, concentrating on the effect on the resources from reasonably foreseeable future actions. The historical discussion, by necessity, is limited to the amount of available information for each resource.

3.3 PROPOSED ACTION AND ACTION ALTERNATIVES

3.3.1 Geology and Soils

3.3.1.1 Affected Environment

3.3.1.1.1 Soils

Soils within the Klamath River watershed span multiple geologies, terrains, and climates. Soil types in the project area can be grouped generally into those on steeper slopes, floodplain or terrace surfaces, or directly along the river itself. Soils on steeper slopes are shallow to moderately deep (typically 17 to 40 inches) and comprise a 7- to 8-inch surface horizon of gravelly loam; an underlying horizon of gravelly, clayey loam; and locally a very gravelly clay (FERC, 1990).

Floodplain or terrace surface soils comprise a deep, well-drained combination of alluvium[19] (and in some places colluvium).[20] These soils as found in the project area within the canyon of the J.C. Boyle peaking reach can be divided typically into a 15-inch very gravelly loam upper horizon, a transitional 6-inch gravelly clay loam layer, and a 39-inch horizon of heavy clay loam underlain by weathered bedrock to 60 inches or more below the surface (FERC, 1990).

The third soil type, located directly along the river, comprises unconsolidated alluvium, colluvium, and fluvial deposits. These geologically recent alluvial, low terrace and landslide deposits consist of unconsolidated sand, silt, and gravels deposited by water or erosion.

3.3.1.1.2 Slope Stability/Landslides

Mass failures and other gravity-driven erosion processes require relatively steep slopes. Such conditions within the project area exist only within the Klamath River Canyon area from J.C. Boyle dam to just downstream of Iron Gate dam. Landsliding outside the project area is prevalent in the Franciscan geology of the lower Klamath River watershed (see section 3.1) and in certain Klamath Mountain province watersheds, such as the Salmon River (de la Fuente and Haessig, 1993).

Surface and subsurface geologic mapping in the area of the J.C. Boyle bypassed and peaking reaches shows a long history of landsliding from the steep valley walls (FERC, 1990). This area contains numerous mass failures including deep-seated rotational landslides, shallow secondary landslides, and rockfalls and slumps on talus-covered slopes. Evidence of rockfalls is apparent above and below the J.C. Boyle canal. On December 2, 2005, a large rockfall collided with the canal wall, blocking an access road and creating a hole in the canal flume (letter from R.A. Landolt, Managing Director, Hydro Resources, to J. Raby, Field Manager, Bureau of Land Management, Klamath Falls, dated December 5, 2005). The resulting canal leak eroded the adjacent road and slope downhill from the canal, forming a debris fan at the river's edge. The canal was repaired by December 13, 2005, and the road opened (letter from R.A. Landolt, Managing Director, Hydro Resources, to J. Raby, Field Manager, Bureau of Land Management, Klamath Falls, dated December 23, 2005).

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[19]Alluvium is material deposited by streams or rivers on a channel's bed, banks, and/or floodplain and on alluvial fans.

[20]Colluvium is loose and incoherent deposits, usually at the toe of a cliff or hillslope, transported primarily via the direct force of gravity.

Occurrence of large landslides is associated with exposure of Western Cascade tuff[21] in roughly the area in the 4 miles of the peaking reach upstream of the California-Oregon state line (RMs 210 to 214) where basalt movement is caused by slip surfaces initiated within the weaker tuff. Individual slide blocks of tuff and basalt involve up to 3,000 feet of canyon wall and may be several hundred feet thick. Some areas have experienced repeated events, and secondary landslides have occurred in the toe wall (leading edge) of some of these slide masses. A large slide dammed the river at RM 214.3 in recent geological time,[22] resulting in accumulation of silty lake deposits up to 200 feet thick above the blockage. These deposits form the terrace areas now referred to as the Frain Ranch area (FERC, 1990).

Other potential landslide/rockfall areas include all steep slopes underlain by tuff, as well as areas of deep colluvium/talus slopes that could produce slumps and debris flows. Talus slopes are found throughout the Klamath River Canyon portion of the project area, and are particularly visible in the J.C. Boyle bypassed reach. Continuous creep of talus and rapid rockfalls are likely on and near the talus slopes, and the potential exists for slow to moderate migration of some of the large slides.

3.3.1.1.3 Klamath River Geomorphology

Channel and Floodplain Morphology

The Klamath River in the project-affected reaches is a predominantly non-alluvial, sediment supply-limited river flowing through mountainous terrain (figure 3-1). For most of its length to the Pacific Ocean, it maintains a relatively steep, high-energy, coarse-grained channel frequently confined by bedrock (Ayres Associates, 1999). Much of the river in the project area is geologically controlled, interspersed with relatively short alluvial reaches. PacifiCorp's pebble count sampling shows broad variation and suggests strong local control on sediment particle size distributions (figure 3-2). Floodplain development is minimal, and wider valleys allowing more alluvial channel migration processes are rare, increasing somewhat downstream of Interstate 5. A variable local climate and geology are reflected in the geomorphic and vegetative characteristics of the river valley, and generally, the channel changes character as it passes from one geologic province to the next (see section 3.1 for province details). The following sections describe the morphology of project-related lake, river, and floodplain environments.

Most information for our description of the project-area geomorphology of the area from Upper Klamath Lake through and including Lower Klamath Lake comes from Reclamation (2005a). Where we use another source, including the project's license application, we indicate it. We also supplement information from available sources with our observations during the publicly noticed site visit (May 18 and 19, 2004) and from a supplemental visit to the project area on August 29, through September 1, 2005.

Upper Klamath Lake (RMs 254.3–282.3). Management of the water surface elevation of Upper Klamath Lake by regulating the outflow did not occur until 1919 by which time 29,000 acres of marshland had been diked off from the natural lake. These dikes separate the lake from pasture land and established a new perimeter for the open water surface of the lake. Groundwater elevations are managed for these reclaimed areas by a series of drains and pumps that discharge the drainwater into the lake. Overall, the combined diking and conversion of marshland, and the regulation of the outflow, has fundamentally changed the lake's hydraulic performance. This likely also includes changes in sediment and nutrient yields to the Link River as well as the area served by the Klamath Irrigation Project via withdrawals from the lake through the A canal (see figure 2-4).

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[21] A general term that can be applied for all consolidated pyroclastic rocks (those explosively or aerially ejected from a volcanic vent).

[22] The American Geological Institute (1984) defines "recent" to be synonymous with the Holocene, a geologic epoch of the Quaternary period, stretching from the end of the Pleistocene, approximately 8,000 years ago, to the present time.

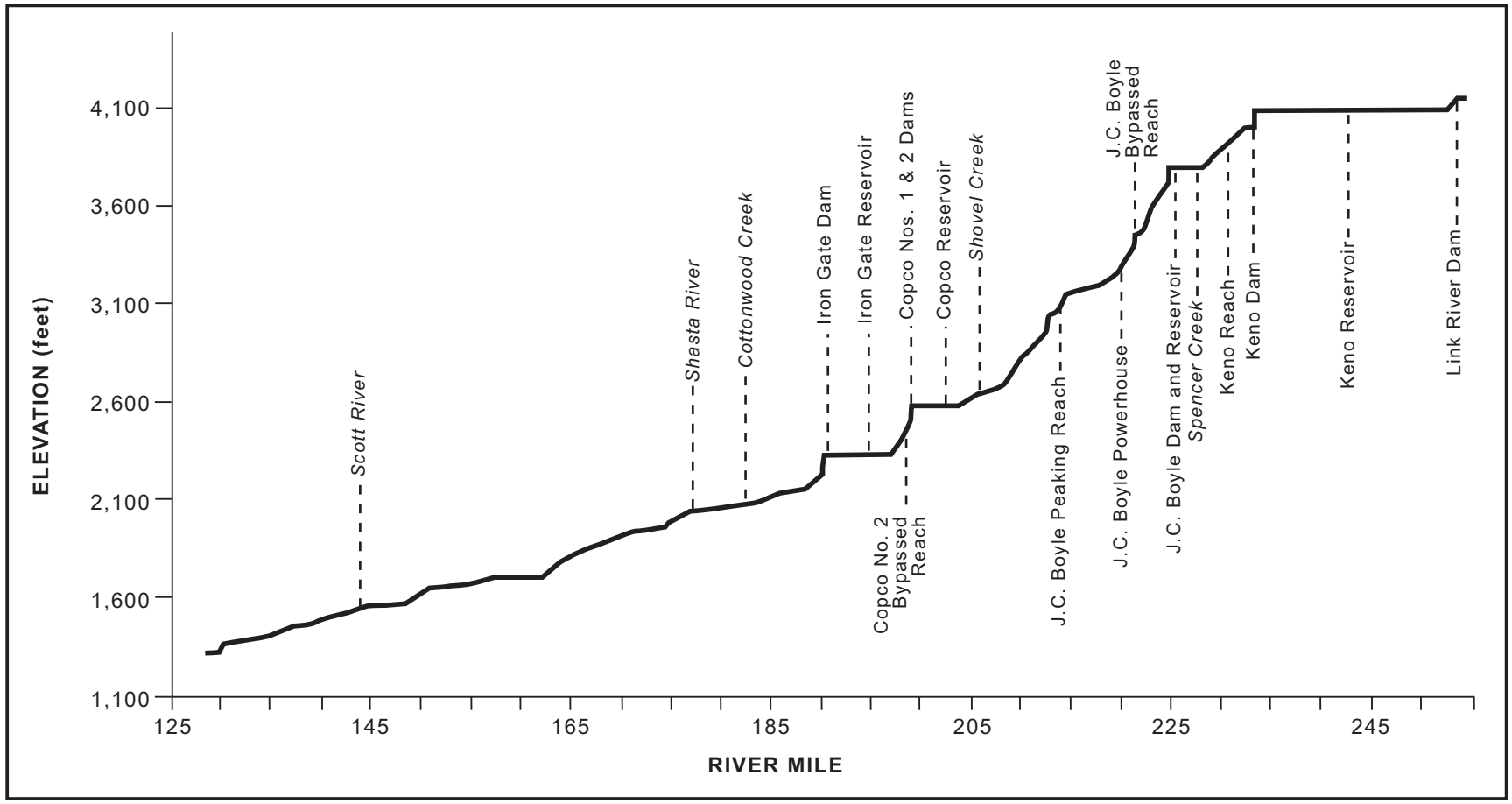

Figure 3-1. Klamath River profile. (Source: PacifiCorp, 2004a)

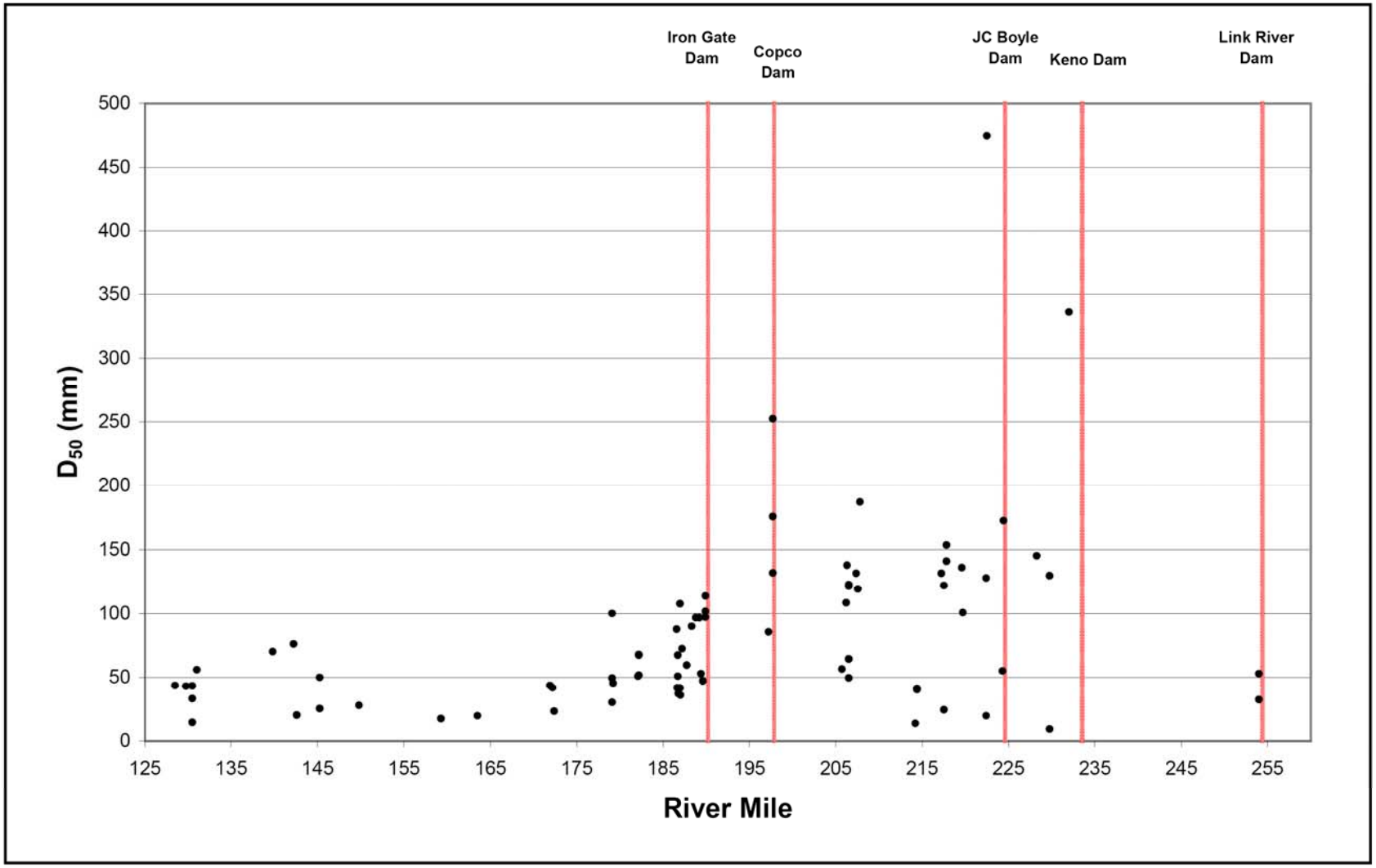

Figure 3-2. Klamath River pebble counts, median (D50) particle size longitudinal distribution. (Source: PacifiCorp, 2004a)

Link River (RMs 254.3–253.1). There is substantial bedrock control throughout most of the Link River reach. Prior to the placement of Link River dam, the river contained a bedrock sill that prevented Upper Klamath Lake from dropping below elevation 4,140 feet (Oregon Water Resources Department, 1999). To gain additional active storage, construction of Link River dam included notching the natural bedrock reef upstream of the dam in the narrows of the lake's outlet. This notching lowered the hydraulic control point 3 feet so the lake could be drawn down to an elevation of 4,137 feet, thus increasing the operational control of the dam.

Downstream of the dam, the Link River channel is composed of bedrock with occasional ledges and some boulders and cobble—a portion of which appear to be related to the construction of the canals. PacifiCorp measured the slope[23] of the channel at about 1.1 percent, and identified a conspicuous bedrock-cored mid-channel island located just downstream of the dam, with low, narrow terraces on either bank. Our observations found the channel to have very limited sediment storage, and we consider it to be historically starved of (at least coarse) sediment by Upper Klamath Lake (Reclamation, 2005a). Very few patches of apparently mobile fine or coarse sediment were present at the time of PacifiCorp's bed material sampling, and the lack of suitable substrate for surface pebble counts confirms that this is a sediment transport reach. We observed that the backwater effects from Keno dam appear to begin to influence the Link River near the Highway 97 overpass (Reclamation, 2005a).

Keno Reservoir (RMs 253.1–233.0). Keno reservoir is a narrow impoundment with a distinct riverine character. PacifiCorp indicates that it attempts to operate Keno dam to maintain the elevation of Keno reservoir at a relatively steady elevation. We observed that, along with dredging, diking, and channelization, these operations have resulted in a relatively stable channel configuration with a grass-lined, moderately sinuous channel with little visible current. The reservoir area is characterized by low topographic relief and was formerly the area where, depending on water levels and discharges, water from Upper Klamath Lake (having flowed through the Link River) could flow down the Klamath River, overflow from Lake Ewauna into the Lost River (via the Lost River Slough), or flow from the Klamath River into Lower Klamath Lake (via the Klamath Straits).

The historical outlet of Lake Ewauna to the downstream Klamath River (about 2 miles downstream of the mouth of Link River) was created by a bedrock reef, which created a drop of about 1 foot during periods of relatively low flow. Adjacent to the reef, a natural overflow channel, the Lost River Slough, carried water out of Lake Ewauna into the Lost River and the closed basin of Tule Lake when the water surface of Lake Ewauna exceeded elevation 4,085 feet.

Prior to human modification, the Klamath Straits (see figures 2-3 and 2-4) were the main natural channel for water exchange between the Klamath River and Lower Klamath Lake. In times of high river flow, the Klamath River would overflow through the straits, flowing to Lower Klamath Lake; during low river flow (and comparatively high Lower Klamath Lake levels) water in the lake would drain back into the Klamath River. That action cut a large channel about 225 feet wide and 20 feet deep. The construction of a railroad grade formed a dike across the northern end of the Lower Klamath Lake, and Reclamation made an agreement with the railroad to place a concrete structure in the straits to control the flow of water from the Klamath River. The straits were excavated and channelized and now function as a drain, conveying drainage water from irrigated land reclaimed from Lower Klamath Lake and from the Lower Klamath National Wildlife Refuge.

Before the construction of Klamath Irrigation Project in the early 1900s, water surface elevations in Lower Klamath Lake and upstream along the Klamath River to the basalt reef-outlet of Lake Ewauna were controlled by a second natural basalt reef located in the river channel at Keno. This reef held water

[23]Slopes are based on PacifiCorp's study reach averages which are shorter, sub-segments of the larger reaches defined in this document. Because survey of the study reaches was targeted in representative locations, these values should approximate the average slope throughout the reach.

levels in Lower Klamath Lake and upstream along the channel to a minimum elevation of about 4,084 feet. At higher flows, water in the river backed up as the water surface of Lower Klamath Lake rose; above a water surface elevation of 4,085.1 feet, Lake Ewauna was inundated and became a continuous part of Lower Klamath Lake. If Lower Klamath Lake/Lake Ewauna water levels were high enough (at and above elevation an elevation of 4,085.1 feet), lake water from the south merged with Lost River Slough and were carried to the Tule Lake Basin. This connection was closed with a dike in 1890. The current Lost River diversion channel (see figure 2-4) was constructed primarily at the former location of the Lost River Slough.

In 1908, the height of the reef at Keno was lowered with dynamite, which lowered the level of Lower Klamath Lake making it suitable for agricultural land and a wildlife refuge (Carlson et al., 2001). However, according to the Klamath Drainage District, the remaining portion of the reef provided sufficient head to meet its water delivery needs and those of the Lower Klamath Lake Wildlife Refuge (letter from S. Henzel, President, Klamath Irrigation District, to the Commission, dated June 16, 2004). When Reclamation constructed the original Keno regulating dam in the vicinity of Keno (a needle-type dam), the remaining portion of the rock reef at Keno was removed, according to the Klamath Drainage District, making it dependent on the regulating dam to provide appropriate head to maintain flow to the district. The original Keno regulating dam, which also supported hydroelectric generation, was damaged during the floods of 1964–1965, and the existing Keno dam now serves to regulate upstream water levels. In addition, the channel upstream of Keno dam between RMs 235 and 249 was dredged between 1966 and 1971 to provide a channel capacity of 13,300 cfs to accommodate inflow from Klamath Irrigation Project canals and reduce the risk of flooding (letter from C. Scott, Licensing Project Manager, PacifiCorp, to the Commission, dated May 16, 2005, responding to an additional information request dated February 17, 2005).

Lower Klamath Lake. Generally, the predevelopment Lower Klamath Lake was a very shallow water body that averaged less than about 5 or 6 feet deep. Inflow to the lake was from backwater overflow of the Klamath River, through the bulrush wetland marsh adjacent to the river, and through the naturally deep channel of the Klamath Straits. Backwater control of this inflow was by the natural bedrock reef at Keno. The broad, wetland marsh surrounding the central, open water area of the lake, grew in very shallow water near the lakeshore.

The greatest expanse of open water was resident in the deeper, southern portion of the lake where evaporation made the lake moderately alkaline. During the most typical years, the stable water surface for the lake was probably about elevation 4,084 to 4,085 feet, although the flood of 1888 was so great that the water surface of Lower Klamath Lake may have exceeded elevation 4,088 feet for a considerable time. Such a flood event would have created a broad, expansive lake that would have included the Klamath River upstream of Keno and Lake Ewauna.

During drought, water drained from Lower Klamath Lake into the Klamath River, and the associated marsh would dry up. Large islands of emergent growth would initially appear and, as dry conditions continued, these islands would become fragmented. Alkalinity in the lake would have increased and caused accelerated deterioration of the bulrush wetlands. Open water areas were somewhat shallower and, during such dry conditions, would have been warmer and more brackish. The water surface of the lake during such dry years may have been about elevation 4,083 feet or lower during much of the summer.

Beginning in 1908, work began to reclaim Lower Klamath Lake for agricultural land uses. The railroad dike was constructed east of the Klamath River, cutting off all flow into Lower Klamath Lake, except flow through the Klamath Straits. By 1917, with closure of the Klamath Straits, the last phase of draining the vast area of open water and marshland of Lower Klamath Lake began. Within a decade, the natural character of Lower Klamath Lake was gone. From 1917 to the mid-1950s, the dry lakebed of Lower Klamath Lake was extensively converted to irrigated agriculture; however, a part of the former

lake was re-flooded and is managed as a wetland complex within the Lower Klamath National Wildlife Refuge. Factors that historically and currently influence geomorphological processes in the Klamath River upstream of Keno dam are predominantly associated with processes at Keno reservoir (Lake Ewauna) and Lower Klamath Lake, and the direct effect of flows from Clear and Tule lakes on the Klamath River would be minimal.

Keno Reach (RMs 233–228.3). This bedrock-controlled section of river is somewhat steeper (average slope is approximately 1.3 percent) than the Link River, and the channel consists of sequences of boulder/bedrock cascades and deep bedrock runs. Steep banks and alternating bedrock terraces confine the channel. Marginal islands occur sporadically, usually associated with bedrock protrusions or accumulations of coarse cobble and boulders. The Keno reach exhibits substantial bedrock control with little riparian vegetation influence. Pebble counts confirm that this is primarily a sediment transport reach; however, local geologic controls provide sheltered depositional areas where relatively fine sediment is deposited and temporarily stored in the channel. The downstream end of this reach is characterized by the transition from the Keno Gorge to the lower gradient and the more open topography that holds J.C. Boyle reservoir.

J.C. Boyle Reservoir and Spencer Creek (RMs 228.3–224.7). J.C. Boyle reservoir is located at a topographic transition on the Klamath River, whereby the wider, shallower upstream-end of the reservoir is sitting atop a formerly lower-gradient reach of river, with wide, grassy floodplain on the left bank and low hills on the right bank near the Spencer Creek confluence. Downstream of the Highway 66 Bridge, the reservoir narrows and deepens, and at about the location of J.C. Boyle dam, the Klamath River begins to enter the basalt cliff-lined canyon that contains the Klamath River all the way into California. We discuss reservoir bathymetry and substrate conditions later in *Reservoir Sedimentation and Dredging*.

Spencer Creek is the only tributary of significance to the J.C. Boyle reservoir, entering on the right bank with little delta deposition found during PacifiCorp's delta topographic surveys. The pre-dam channel of the creek was braided near the confluence area (except at the very final approach to the river), and it appears that a topographic control existed that created a braided, depositional reach upstream. PacifiCorp's review of historical aerial photographs indicates that much of the braided nature of the creek channel in this area has diminished over time, and only limited vegetation encroachment into the channel has occurred.

J.C. Boyle Bypassed Reach (RMs 224.7–220.4). The J.C. Boyle bypassed reach begins just downstream of J.C. Boyle dam, and is also the beginning of the Klamath Gorge and an associated increase in channel slope (averaging from 1.4 to 2.3 percent through the bypassed reach). Generally, the slopes of the gorge are stable except for numerous talus slopes (accumulations of rock colluvium at the base of cliffs or on steep slopes) and loose pieces of basalt that occasionally fall from the cliffs. Sloughing talus and basalt fragments commonly extend down the valley walls to the river (FERC, 1990).

In the upper portion of this reach (from RMs 224.5 to 222.5) much of the river is flanked on the right bank by a maintenance road and the J.C. Boyle canal until the canal transitions to a tunnel through Big Bend[24] to the J.C. Boyle powerhouse penstock. Construction of the road and canal on the steep canyon wall in this reach resulted in deposition of sidecast rock and soil material on the hillslope directly adjacent to the river, in some cases eliminating the river's already-small floodplain and spilling into the channel and locally affecting the river's substrate composition. Natural colluvial material forms an apron on the lower slopes of the canyon along much of the left bank of the river in the bypassed reach, generally in the area from RMs 224.3 to 221.6.

[24]Big Bend is a prominent, elongated ridge around which the river flows in a relatively tight bend controlled by the narrow canyon topography.

The channel through this reach is often V-shaped and consists primarily of boulder and bedrock. Other sections consist of a coarse plane-bed[25] with large boulders (and sidecast material in some areas), with gravel and cobble on small bars and in pockets created by coarser material. The channel morphology of the river upstream of the canal emergency spillway (located at the upstream end of Big Bend, just upstream of the entrance to the tunnel leading to the penstocks for the J.C. Boyle powerhouse) consists of alternating pools and boulder cascades. The channel slope of the J.C. Boyle bypassed reach downstream of the emergency spillway is one of the highest in the project area at 2.3 percent and may be related to substantial input of coarse sediment from the large eroded area at the base of the emergency overflow spillway. Although the transport capacity is high for the reach (due to the high local slope), PacifiCorp states that sediment is added frequently to the channel from operation of the canal spillway. We discuss the erosion at the toe of the spillway in greater detail later in *Other Sediment Inputs*.

The downstream portion of the bypassed reach is substantially different from the channel upstream of the emergency spillway. Boulder runs contain substantial pockets of fine sediment, and boulder and coarse cobble riffles exist. Downstream of the emergency spillway, the channel appears to be adjusting to the sediment input from operation of the overflow spillway. The road and its fill slope are far above the river and do not influence the channel or its floodplain. The reach ends at the downstream end of Big Bend (RM 220.4), where the J.C. Boyle powerhouse reintroduces river flows diverted at the dam.

J.C. Boyle Peaking Reach (RMs 220.4–203.1). The J.C. Boyle peaking reach begins as a broad, plane-bed channel, just downstream from the powerhouse. The channel remains steep and full of scattered boulders until downstream of the Spring Island boater access at the USGS gage (RM 219.7). Downstream of this location, while still steep, the channel is characterized by alternating cobble riffles and runs, with cobble bar and pool morphology. The gradient of the river remains high (about 1.7 percent) in the first mile or so; however, local areas of sediment deposition (e.g., bars, terraces) also begin to become present. In this area, the channel is flanked by relatively wide terraces at multiple levels. These terraces are related to the thick prehistoric lacustrine[26] deposits found in the river canyon from a short distance downstream of the J.C. Boyle powerhouse downstream to RM 214.3.

By RM 217 the river is much less steep (slope of about 0.3 percent), and the lacustrine terraces are relatively wide and conspicuous. The decreased channel gradient allows for an increased frequency of depositional areas through this area, and the pebble counts in this area highlight the storage of relatively fine sediments (gravel and fine cobble). The terraces of the Frain Ranch area (upstream of RM 214.3) are open, grassy, and very noticeable.

At RM 214.3, the river drops into Caldera Rapid. From this point downstream for about 5 miles the river becomes extremely confined, and the channel gradient increases to 2 percent through this steepest section of the peaking reach. The river is characterized by steep bedrock and boulder cascades and the channel bed, channel margins, and steep banks consist of large boulders and bedrock outcrops, which hinder development of laterally extensive riparian vegetation. PacifiCorp identified small patches of fine gravel behind boulders at the margin of the gorge. Frequently, oak woodland species overhanging the steep, bedrock banks take the place of riparian vegetation. We identified one noteworthy mid-channel bar that stretches from RMs 210.4 to 210.25. It is a very mature feature that includes cobble- and boulder-sized sediment, and is vegetated with a mature forest of both riparian and oak woodland species.

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[25]Plane-bed channels lack well-defined bed forms and are characterized by long stretches of relatively planar channel bed that may be punctuated by occasional channel-spanning rapids (Montgomery and Buffington, 1997).

[26]Lacustrine is pertaining to, produced by, or inhabiting a lake or lakes.

Gradient begins to decrease a bit by RM 210.2, and unscreened gravity-fed water diversions[27] at RM 209.7 (leading to a canal on the left bank) and at RM 209.4 (leading to a canal on the right bank) remove water from the river via localized alterations to the channel. These diversions do not contain any concrete or other formally constructed features; instead, they are formed from natural bed material—mostly cobble-sized sediment—that appears to us to be bermed up via heavy equipment to connect the ditch inlet to the river elevation.

Near the California-Oregon state line (RM 209.3) the river canyon begins to open, and there is a decrease in channel slope. Alternating pools, bars, runs, and riffles characterize this section of the reach, which has a relatively low gradient (about 0.8 percent). A comparatively wide terrace that supports a riparian corridor of varying width borders the channel, beyond which there is a floodplain that supports mostly irrigated pastureland. This general channel and floodplain configuration continues, with pasture on one or both banks, for the next 5 miles. In this reach of river, several side channels exist in conjunction with lateral bars and islands. At RM 206.5, Shovel Creek, the largest tributary in this reach, enters the Klamath River on its left bank. The reach ends at Copco reservoir (RM 203.1).

Copco Reservoir and Tributaries (RMs 203.1–198.6). Copco reservoir is located at a topographic transition on the Klamath River, whereby roughly the upper 80 percent of the reservoir is sitting atop a formerly lower gradient reach of river, with a steeper reach of river (still visible in the Copco No. 2 bypassed reach, described later) located downstream. This break in stream gradient is largely the result of Pleistocene-aged cinder cones and associated lava flows at the downstream end of Copco reservoir. The lower gradient upstream portion of the reservoir is likely the result of extensive valley-fill alluvium upstream of that lava flow (which likely dammed the river for some period of time). We discuss reservoir bathymetry and substrate conditions later in *Reservoir Sedimentation and Dredging*.

Several streams enter Copco reservoir, including Long Prairie Creek (the largest), Beaver Creek, Deer Creek, and Raymond Gulch, and multiple springs emerge from the hillside above the reservoir northeast of Copco Cove. Sediment deposition and/or delta formations are present at the mouths of the larger tributaries. We also observed sediment deposition via shoreline erosion in the vicinity of Beaver Creek Cove, adjacent to Copco Road and along the opposite (southern) shoreline of Copco reservoir during an August 30, 2005, visit to this area.

Copco No. 2 Reservoir (RMs 198.6–198.3). Copco No. 2 reservoir is a relatively short (just over 0.25 mile) impoundment, formed by the 33-foot tall Copco No. 2 dam. The reservoir is narrow, confined by a narrow bedrock canyon formed by the previously mentioned lava flow. No reservoir bathymetry or substrate information is available for this reservoir.

Copco No. 2 Bypassed Reach (RMs 198.3–196.9). Downstream of Copco No. 2 dam, the Copco No. 2 bypassed reach is characterized by a confined, boulder- and bedrock-dominated channel. The average gradient of the reach is about 1.9 percent. Fossilized[28] boulder-cobble bars have become dominated by very mature alders, but also include individual sycamore and maple trees, and these bar features dominate the channel cross section. PacifiCorp measured the surface median grain size on a fossilized bar as about 10 inches, compared to about 3 inches for the surface of an active bar. Bedrock ledges also exist within the reach. Because of the steep canyon topography—the river in this reach is strongly influenced by the lava flow on the north (right bank) side of the river—there are minimal

[27]These diversions lead to PacifiCorp's Copco Ranch (a non-hydro related property).

[28]Fossilized refers to a condition whereby the bar deposit has been totally stripped of finer sediment, leaving only the coarsened fraction of the point bar that is unable to be moved by the river. Under an altered flow regime such as the Copco No. 2 bypassed reach, river flows are never sufficient to mobilize the bar, leaving it essentially frozen in place or fossilized. Vegetation growth can further fossilize the bar surface.

floodplains in this reach. At RM 196.9, the Copco No. 2 powerhouse discharges water back into the Klamath River, and, roughly coincident with this location, the reach ends at Iron Gate reservoir.

Iron Gate Reservoir and Tributaries (RMs 196.9–190.1). Iron Gate reservoir overlies a topographic transition on the Klamath River, where a steeper reach of river upstream (that of the Copco No. 2 bypassed reach and a portion of the river inundated by Copco reservoir and Copco No. 2 reservoir) transitions into the lower gradient reach downstream of Iron Gate reservoir. In this area, the topography opens up, and the restrictions on the channel placed by the localized basalt flow (north of the Copco No. 2 bypassed reach) are relieved. We discuss reservoir bathymetry and substrate conditions later in *Reservoir Sedimentation and Dredging*.

Several sizeable tributaries enter Iron Gate reservoir on its right (north) bank, many with delta formations at their mouths. Fall Creek enters at RM 196.3 in a disturbed area,[29] and there are no signs of deposition via PacifiCorp's survey and review of historical aerial photograph analysis. We also observed that the confluence with the reservoir is within the upper end of the reservoir, and depending on reservoir stage the river may flow at this location (versus being constantly impounded), potentially transporting sediment and precluding delta formation. Jenny, Camp, Dutch, and Scotch creeks all display signs of substantial deposition at their confluences with the reservoir. We discuss details of these depositional features and the sediment supply later in *Reservoir Tributary Sediment Yield Data*.

Iron Gate Dam to Seiad Valley (RMs 190.1–130). Below Iron Gate dam, the river flows through a narrow valley cut into Cascade volcanic rocks; it has alluvial features, but with frequent bedrock outcrops in the bed. The reach is characterized by alternating coarse cobble-boulder bars and cobble runs. The average gradient ranges from about 0.16 to 0.4 percent in the first 5 miles below Iron Gate dam. A narrow, discontinuous floodplain and extensive high terraces border the channel. Small deltas have formed at the tributary confluences with the Klamath River that are composed of finer grained material than the mainstem. At RM 184 (near the Klamathon Bridge), the valley begins to widen, and by the confluence with Cottonwood Creek (RM 182.1) the river is flowing through a broad valley, formed by the intersection of the Klamath and Cottonwood drainages.

The Cottonwood Creek watershed is not a major source of sediment to the Klamath River; however, along with Bogus and Little Bogus creeks, these tributaries are the first potential sources of sediment downstream of Iron Gate dam and may contribute sediment at higher flows (Ayres Associates, 1999; Buer, 1981). Extensive placer and hard rock mining have occurred in Cottonwood Creek and its watershed, especially near the towns of Hornbrook and Henley (Ayres Associates, 1999). Buer (1981) indicates that the creek has been mined for its gravel for the construction of Interstate-5 and other purposes, and that only minor deposits remain. Similarly, Ayres Associates (1999) observed the Cottonwood Creek channel about a mile upstream of its confluence with the Klamath as "floored by bedrock and scoured clean of any significant alluvium."

Less than a mile downstream of Cottonwood Creek the valley again constricts, with a V-shaped valley formed by bedrock and colluvial material. Downstream of Interstate-5 (at RM 179.2), the river begins to cut through the Klamath province, and the channel is steeper and bedrock-controlled, with limited accumulations of alluvium. In this section of river, the channel is confined between canyon walls with a cobble-gravel bed and well-developed pool-riffle morphology flanked by discontinuous floodplain and minimal terraces. Bars from the confluence of Cottonwood Creek to Scott River appear to consist of finer material with increasing distance downstream; the median grain size on a bar at the upstream extent of the reach is about 2 inches, compared to about 1 inch at the downstream extent of the reach. Unlike the bars, the median grain size in riffles at the upstream and downstream extent of this geomorphic reach

[29]PacifiCorp notes that hydroproject development and other grading in the vicinity of the delta deposits affect the deposits directly, or compromises its ability to interpret the deposits (GM&A, 2003).

remained consistent at about 2 inches. High terraces are no longer extensive and discrete delta deposits and downstream bars occur at tributary confluences.

The Shasta River (at RM 176.6) may be a source of suspended sediment and possibly some sand and finer gravel (Ayres Associate, 1999). This is consistent with the morphology of the watershed where the broad Shasta Valley and low-gradient meandering channel within it likely intercept and store most of the coarser sediment from the upper watershed (Ayres Associates, 1999; USGS, 2006b; Buer, 1981). Downstream of the Highway 263 crossing, the Shasta River leaves its relatively flat, Shasta Valley alluvial section and drops into a steep, narrow bedrock canyon surrounded by high, steeply sloping mountainsides. The highway cuts into these steep hillsides, with fillslopes spilling down to the river. These fillslopes may be a minor source of fine sediment (Ayres Associates, 1999), in addition to the agriculture sources upstream. The lower gorge of the river contains little evidence of a major sediment supply, and the lack of any substantial sedimentation in the Klamath River at the confluence, or downstream, suggests that the Shasta River does not supply much coarse sediment to the Klamath River (Ayres Associates, 1999).

From RMs 172 to 169 there are signs of floodplain and near-channel mining[30] activities, with tailings piles still observable in some floodplain areas. Here and in the miles downstream, the steep, mountainous terrain in part dictates valley width, which in turn controls channel form. Valley width ranges from as narrow as 300 feet (with the river occupying most of the valley bottom) to almost 1,200 feet; the average is about 650 feet. Channel slope is roughly correlated with valley width, whereby steeper sections of channel occur in the more-constricted narrow valley sections. Wider valley sections typically promote lower gradient channel sections and more frequent alluvial features and floodplains; however, the size of alluvial features is largest in the miles downstream of major confluences (i.e., the Shasta and Scott rivers), and does not increase markedly to amounts greater than about 17 acres/mile until after the confluence with the Scott River (RM 143).

The Scott River is considered a major source of fine sediment (Ayres Associates, 1999). Extensive erosion of hydraulic mine sites and extensive in-channel placer and dredge mining sites upstream—along with timber harvest and fires in the upper watershed—are sources of this sediment (Ayres Associates, 1999). Scott Valley lies 35 miles upstream of the confluence with the Klamath River, and the conspicuous northeast-southwest trending Scott Bar Mountain forces the river in a large bend to the west before it can again flow east and then north to meet the Klamath River. This reach of river from Scott Valley to the confluence is steep and geologically controlled.

There are noteworthy gravel/cobble bars located at the Scott River confluence with the Klamath River, and PacifiCorp noted increased amounts of sand and fine gravel in pebble counts with distance downstream. Downstream of the confluence of the Scott River, the channel is made up of finer grained materials compared with the upper reaches. The median grain size for the five pebble counts conducted on bars ranged from 1.3 to about 3 inches; for the three riffles where pebble counts were conducted in this reach, the range was from 0.6 inch to 1.7 inches. Near Seiad Valley (RM 130) the river is still characterized by gravel/cobble bars, riffles, and runs. Locally, channel slope is less than at upstream locations and there has been extensive gold and gravel mining in the floodplain area of Seiad Valley.

<u>Seiad Valley to Confluence with the Pacific Ocean (RMs 130–0)</u>. The Klamath River from Seiad Valley to the Pacific Ocean maintains similar channel conditions to those described for the reach from the Scott River to Seiad Valley, albeit with a progressively larger channel and lower gradient. Major tributaries entering the Klamath River include the Salmon River at RM 66.0 and the Trinity River at RM 40.0. Numerous smaller creeks enter on both banks. Steep tributaries entering the river occasionally contribute sediment via debris torrents, with resultant alluvial fans forming at their mouths. Bedrock

[30]Such mining would be for gold, using dredges, and later for gravel to be used as aggregate for construction.

outcrops constrict the river at some locations, and larger rapids are formed by boulder bars/cascades (for example, landslide debris, debris fan deposits, bedrock and a major constriction of the valley at Sugarloaf Mountain produce Ishi Pishi Falls [RM 66.5], upstream of the mouth of the Salmon River).

The Salmon River is a substantial source of sediment and a major contributor of sand and gravel (Ayres Associates, 1999). The watershed drains several large areas of plutonic (granitic or dioritic) rocks which produce large volumes of fine sediment. The local channel morphology of the Klamath River (narrow bedrock constriction) downstream of the confluence precludes local storage of sediment from the Salmon River, and there is no fan or delta at the confluence (Ayres Associates, 1999).

The Trinity River (RM 40.0) is a major source of sediment, albeit somewhat finer than other large tributaries (Ayres Associates, 1999). The channel of the Trinity upstream of the confluence with the Klamath River is confined by a narrow bedrock valley with little sediment storage and terrace development. Upstream, the South Fork Trinity maintains a largely natural hydrograph (it is free of large dams), but the larger mainstem Trinity is controlled by Lewiston and Trinity dams. These two dams are an integral part of the Central Valley Project's Trinity River Division (TRD) since they were constructed in the 1960s and allow for the transfer of Trinity River water into the Sacramento River Basin. Out-of-basin diversions by the TRD averaged nearly 90 percent of the upper Trinity Basin inflow for the first 10 years of full TRD operations (Interior, 2000). These dam operations eliminate nearly all high flows responsible for forming and maintaining dynamic channel processes. No longer scoured, riparian vegetation encroached on the channel, creating lateral riparian berms. Combined with a loss of coarse sediment, this caused the mainstem Trinity River to change from a series of alternating riffles and deep pools (which provided good salmonid habitat) to a largely monotypic run habitat confined by the berms (FWS and Hoopa Valley Tribe, 1999).

Since December 2000, when the Trinity River Mainstem Fishery Restoration Record of Decision (ROD) was signed, the Trinity River Restoration Program[31] has implemented variable flow releases (based on water type year) to meet various restoration objectives and management targets. To recreate inter-annual, or "between-year" flow variability, the ROD defined five water year types with a minimum volume of water to be released into the Trinity River for each type. Each year, the water not allocated to the river is available for export to the Central Valley Project for water supply and power generation. Other components of the restoration program include implementing fine-sediment reduction and coarse-sediment augmentation projects to restore the river's altered sediment budget because of operation of Lewiston and Trinity dams, and mechanical channel rehabilitation to remove fossilized riparian berms along the banks of the river that prevent access by the river to the historic floodplain.

Sediment Supply

Sediment is supplied to stream channels through mass wasting (landslides, debris flows, earthflows), sheetwash, gullying, bank collapse, fluvial erosion (bank erosion, channel avulsion), dry ravel (loss of cohesion in surface materials), tree throw, wind erosion, animal action (e.g., burrowing), and soil creep. Sediment supply via these sources often is affected (and typically increased[32]) by land use-related activities such as grazing, agriculture, timber harvest, road building, mining, and urbanization.

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[31]The Trinity River Restoration Program has four main organizational elements: The Trinity Management Council, the Trinity Adaptive Management Working Group, the Adaptive Environmental Assessment and Management Staff, and the Scientific Advisory Board. These elements work together to develop and implement a management program to restore the fish and wildlife populations in the Trinity River Basin to levels that existed prior to construction of Trinity and Lewiston dams.

[32]Important exceptions to this include dredging, gravel mining, and dams which remove sediment from channels and/or floodplains.

PacifiCorp assessed sediment contribution from bank erosion, bank collapse, and tree throw through review of aerial photographs. Many channel banks in the study area are composed of bedrock, boulders, and cobble, and thus only subject to minor erosion. Alluvial deposits do not dominate the river landscape through the project-affected reaches. Bank collapse in a few locations in the steeper canyons did not appear to be a substantial source of sediment. Tree throw, which was limited along the mainstem Klamath River, also is not a substantial source of sediment.

Information on sediment supply to the river in areas downstream of the project area is somewhat limited. Sommarstrom et al. (1990) investigated sediment supply in the Scott River watershed (entering the Klamath River at RM 143, about 47 miles downstream of Iron Gate dam) coming from sub-watersheds dominated by granitic geology. Differing markedly from the Salmon River Basin (described below), the dominant sources of sediment in the surveyed part of the Scott River watershed were found to be roads and skid trails (75 percent) and streambanks (23 percent). The study estimates that, on average, upland erosion in the granitic sub-watersheds[33] of the Scott River produce 1,011 tons/mile^2/year; however, the amount of sediment delivered to the Scott River (using the preferred sediment delivery factor of 0.21 as specified in the study) is 212 tons/mile^2/year.

In 2005, the California State North Coast Regional Water Quality Control Board (NCRWQCB) produced a staff report delineating total maximum daily load (TMDL) allocations of sediment for the Scott River watershed (NCRWQCB, 2005). Analysis in that report reviewed, and to some extent integrated, data from Sommarstrom et al. (1990), as well as new data from the study's own field work. The report estimated that the current sediment load (yield) in the Scott River watershed is 747 tons/mile^2/year. Of that total, 299 tons/mile^2/year were estimated to be from sources associated with human activity.

A Forest Service study (de la Fuente and Haessig, 1993) systematically measured landslides and estimated sediment yields for the Salmon River, which joins the Klamath River at RM 66, about 124 miles downstream of Iron Gate dam. Differing markedly from the Scott River Basin, this study found that, for the Salmon River watershed, mining and landsliding are the major sources of sediment, contributing 57 and 38 percent of the total sediment volume from 1904 through 1989, respectively. Surface erosion contributed another 5 percent; channel erosion was not quantified, but a large portion was observed to be "directly related to landsliding." De la Fuente and Haessig estimated the sediment yield from the Salmon River under current, disturbed conditions at between[34] 460 and 570 tons per square mile per year (tons/mi^2/yr). This sediment yield estimate is for total load—the sum of bed load and suspended load. According to PacifiCorp, the Salmon River sediment yield estimates of de la Fuente and Haessig were later calibrated to 450 tons/mi^2/yr by observations during the 1997 water year; however, the 1993 Forest Service study contains no information on this calibration. It is noteworthy that the 1997 water year contained a particularly high flow event (70,800 cfs[35] on January 1, 1997; flows from December 30, 1996, through January 3, 1997, averaged over 35,000 cfs; USGS, 2006c), which was one of the highest flows on

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[33]Sommarstrom et al. (1990) reported that sub-watersheds dominated by granitics comprise approximately 41 percent of the Scott River watershed, leaving 59 percent of sub-watershed lands as without granitics. NCRWQCB (2005) used more-refined GIS techniques to account for the actual watershed area underlain by granitics (rather than lump entire watersheds as "granitic" or "not granitic"), and found the 11 percent of the Scott River watershed area was underlain by granitics, and 10 percent of the stream miles passed through granitic geology.

[34]Sediment yields reported in the study were originally in units of yards^3/mile^2. We converted these units using the two conversion factors noted in PacifiCorp's license application: 1.2 tons/yard^3 and 1.485 tons/yard^3, yielding values of 460 and 570 tons/mi^2/yr, respectively.

[35]As gaged on the Salmon River at Somes Bar, California, 1 mile upstream of the confluence with the Klamath River.

record. Because of this, we conclude that the 1997 water year may be anomalous and perhaps not appropriate for calibrating sediment yields.

Reservoir Tributary Sediment Yield Data

Streams that flow into the Klamath River deliver both bed load and suspended load to the mainstem. PacifiCorp conducted a survey of representative delta deposits (formed where tributaries flow directly into project reservoirs) to quantify sediment supply (particles larger than 0.8 inch) from tributaries. Surveys of tributary deltas included a combination of detailed bathymetric and terrestrial surveys. Detailed field surveys of the entire delta deposit were completed and compared to the pre-dam topography obtained by PacifiCorp. The process included field surveys, preparation of digital terrain models for both sets of survey data, and computation of net change in volume between the two surfaces.

Table 3-1 presents the results of PacifiCorp's sediment yield estimates based on the field surveys and analyses. Average unit yield (tons/mile^2/year) is computed based on the drainage area and the number of years since closure of the dam. An estimate of 20 percent washload also is added to the yield to reflect the very fine-grained sediments that would not likely be deposited in the delta. This percentage is simply an estimate based on limited suspended sediment size distribution data from the Shasta River (the nearest watershed with such data that drains mostly volcanic terrain) where approximately 20 to 30 percent of the suspended sediment load was in the clay and silt size classes.

Using two different bulk density factors, the computed yields range from 1.3 tons/mile^2/year for Spencer Creek (which flows into J.C. Boyle reservoir) to 220 tons/mile^2/year for Scotch Creek, an obviously large range spanning two orders of magnitude. We concur with PacifiCorp that the values for Spencer and Jenny creeks (18 tons/mile^2/year to 22 tons/mile^2/year) seem unreasonably low. Potential reasons for unexpectedly low yields in these tributaries include upstream water supply reservoirs, channel alterations, or other disturbances that could trap some sediment, or perhaps sediment is being deposited in a location upstream of the surveyed deltas. Scotch and Camp/Dutch creeks have generally similar yields ranging from 134 tons/mile^2/year to 220 tons/mile^2/year, depending on bulk density values. Because the deltas of Scotch and Camp/Dutch creeks have merged together within Iron Gate reservoir, we agree with PacifiCorp that combining the two sites and computing a combined sediment yield is the most appropriate method. Given this, a reasonable long-term sediment yield from Iron Gate tributaries is in the range of 150 to 190 tons/mile^2/year.

Other Sediment Inputs

PacifiCorp undertook a reconnaissance-level analysis of aerial photographs and limited field observations to identify project-related sediment sources. This analysis reported relatively few obviously active, measurable sources of sediment. The principal sources were generally associated with the J.C. Boyle canal emergency spillway, its sidecast boulders, and gullies eroded into the slope below the canal road. Another source, which was not found to be related to project operations, was a large earthflow on the left bank immediately downstream of the USGS gage near Bogus Creek. However, without a basis to infer movement rates, PacifiCorp was unable to turn these observations into a rate of sediment yield.

Spills from the emergency spillway have eroded the side of the hill. PacifiCorp conducted a survey of the eroded hillside between 2003 and 2004 and found the volume of eroded material to be about 68,740 cubic yards.

Table 3-1. Computation of tributary sediment yields from reservoir delta deposits. (Source: GM&A, 2003; as modified by staff).

	Scotch	**Camp/Dutch**	**Scotch/Camp/ Dutch Combined**	**Jenny**	**All Iron Gate Tributaries Combined**	**Spencer**
Deposit volume (yd^3)	88,500	73,500	162,000	107,200	269,200	2,812
Drainage basin area (mi^2)	17.94	19.72	37.65	209.89	247.54	84.62
Period (years)	40	40	40	40	40	36
	Yield Using Bulk Density Value Of 1.485 tons/yd^3 (110 pounds/ft^3) or 1.2 tons/yd^3 (88 pounds/ft^3)					
Yield (tons/mi^2/year)	183.2/148.0	138.4/111.8	159.7/129.1	19.0/15.3	40.4/32.6	1.4/1.1
Add 20% for washload (tons/mi^2/year)	219.8/177.6	166.1/134.2	191.7/154.9	22.8/18.4	48.4/39.1	1.6/1.3

Construction of the canal and canal road involved considerable sidecasting of material excavated from the hillslope, and much of this sidecast material is still present as unweathered boulder-sized blocks on the north slope of the canyon. PacifiCorp reports that historical photographs document encroachment of sidecast material into the channel at only one location (about 4,800 feet upstream of the emergency spillway), a highly visible site where the sidecast material crossed the channel, creating a dam. The dam has partially washed out but still creates a pool upstream, and the mass of material from the right bank deflects flow into the left bank. PacifiCorp states that the left bank is undercut for nearly 400 feet, which has produced an estimated 10,200 cubic yards of sediment. Elsewhere, the sidecast material has narrowed the channel by causing the right bank to extend into the channel.

Another visible source of sediment in the J.C. Boyle bypassed reach is rill and gully erosion on the slope below the canal road. PacifiCorp estimates that this rill and gully erosion yielded a total minimum sediment volume of about 1,500 cubic yards based on measurements of the dimensions of four of the larger gullies.

PacifiCorp also identified three small landslides in the J.C. Boyle bypassed reach. All three slides were located at the downstream end of the J.C. Boyle bypassed reach at Big Bend (table 3-2). The slides were relatively small, and two were related to the presence of road cuts. Slides of similar volume could have been obscured by vegetation along the channel in other locations. Additionally, numerous debris chutes were observed in the reaches that are confined by steep canyons, but PacifiCorp considered these chutes too narrow to be accurately mapped. Thus, PacifiCorp felt this analysis underestimates the contribution of sediment from narrow chutes along the channel.

Table 3-2. Measured landslide sediment volumes in the J.C. Boyle bypassed reach. (Source: PacifiCorp, 2004g, table 6.7-10)

Slide ID	Volume of Slide Accessible by Channel (yd^3)	Mass of Slide Accessible by Channel (tons)	Slide Age (years)	Slide Yield to Channel (tons/year)
Big Bend 1	376	558	51	11
Big Bend 2	1,510	2,242	46	49
Big Bend 3	590	876	46	19

Contribution of sediment to the mainstem Klamath River from hillslope landslides appears limited compared to the contribution from tributaries. PacifiCorp estimates that 79 tons per year of sediment were delivered to the J.C. Boyle bypassed reach channel from measured landslides compared to more than 5,000 tons per year of sediment contributed by tributaries.

Reservoir Sedimentation and Dredging

Bathymetric surveys were conducted on Keno, J.C. Boyle, Copco, and Iron Gate reservoirs in fall 2001, with additional survey work on Keno reservoir in August 2003. Beyond producing data and imagery of existing bathymetry, these surveys also provided the data for estimates of reservoir sediment accumulation and reservoir surface substrate composition. Keno reservoir is the only project reservoir where dredging has occurred. Dredging at Keno occurred shortly after dam construction (1966 through 1971), and, in 2002, about 17,000 cubic yards of material was removed from above the dam to enhance flow to the fish ladder exit to the reservoir.

Comparison of Bathymetry with Historical Topography

Accumulated sediment in the impoundments was assessed by comparing the current bathymetry of the impoundments with pre-impoundment topography. Preconstruction topography was used to generate a surface to compare with the current bathymetry. Because no historical topographic map was available for Lake Ewauna, this area was not included in the historical comparison. Furthermore, bathymetry within the historic river channels of the impoundments was unavailable except for the part of Keno reservoir in the reach between Highway 66 and the dam. This is important because in some reservoirs (e.g., J.C. Boyle reservoir downstream of the Highway 66 Bridge) this is where most of the reservoir depth occurs.

Pre-impoundment mapping often is at lower resolution or contains data alignment irregularities, compared to recent bathymetry. Because the comparison of any two data sets is only as precise as lowest quality data set, interpretation of results can be problematic. This is the same difficulty encountered in the reservoir tributary delta sediment yield study discussed previously. Because of such errors and alignment issues, PacifiCorp points out the reservoir sediment accumulation assessments may be unreliable (letter from C. Scott, Licensing Project Manager, PacifiCorp, to the Commission, dated May 16, 2005, in response to AIR WQ-2 [e]). For example, alignment issues are particularly egregious for the upstream end of Copco reservoir, an area we would suspect to have perhaps the most sediment accumulation of all project impoundments because of its age and location at the upstream end of the reservoir. Table 3-3 presents the results (rounded to the nearest acre-foot) of PacifiCorp's assessment of reservoir sediment accumulation. Note that only current bathymetry is available for the full reach between Lake Ewauna and Keno dam.

Table 3-3. Estimated loss in reservoir volume based on comparison of current bathymetry with historic topography for four of the five study sites. (Source: Eilers and Gubala, 2003, as modified by staff)

Reservoir	Historic Reservoir Volume (acre-feet)	2001 Surveyed Volume[a] (acre-feet)	Loss in Volume (percent)
Keno[b]	926	837	9.6
J.C. Boyle	2,281	2,267	0.6
Copco reservoir	39,601	33,724	14.8
Iron Gate	53,926	50,941	5.5

[a] Additional survey work was conducted in Keno reservoir in August 2003.

[b] Historical topographic mapping was not available for Lake Ewauna, the upstream-most 2 miles of what is now Keno reservoir. Therefore, this estimated loss in volume only includes Keno reservoir below the historic downstream limit of Lake Ewauna.

Reservoir Substrate Composition

During fall 2001, PacifiCorp sampled reservoir surface sediment for subsequent particle size and chemical analyses at 41 locations within project reservoirs, with 20 successfully sampled cores. These samples obtained a shallow sample (generally less than or equal to about 4 inches) using either a mini-Glew gravity corer or an anchor of undefined type. PacifiCorp also undertook detailed hydroacoustic imaging of sediment regularity and reflectivity (Eilers and Gubala, 2003). The data on particle size and other observations were integrated with the unsupervised hydroacoustic imaging of the sediments by

combining hydroacoustic images of similar type to yield a "supervised" map of sediment composition.[36] The resulting data show the differences in sediment composition of the project impoundments.

These data describe only surface sediment, however, and do not necessarily provide an indication of the dominant sediment accumulation (which may exist as a different size class at depth) at any particular location. The sediment samples used to classify the acoustically sensed substrate types are shallow (4 inches or less), and the hydroacoustic beams do not penetrate deeply into the sediment. As such, accumulated sediment mapped as silt could actually be a silt or soil layer covering coarser substrate, such as gravel; conversely, areas mapped as gravel could be sitting atop buried layers of finer sediment.

Another important consideration is related to the coarser fraction of sediment that is generally referred to as rock or gravel in the core results. Neither term necessarily differentiates between the various rock types (such as bedrock, cobble, or gravel) to be expected in the reservoir bed, because all of these rocky substrate types will not enter the mini-Glew gravity corer. When assigned by PacifiCorp, it appears that this sediment type was typically inferred qualitatively, either through underwater video or based on refusal of the sampler or anchor.

Keno Reservoir Dredging and Spoil Disposal Sites

The original Keno needle-type regulating dam was damaged during the floods of 1964 to 1965, and a new dam was constructed to replace it. In addition, channel improvements between RMs 234.6 and 236 were completed during the construction of the new dam in 1966, and channel improvements from the Highway 66 Bridge (RM 235) to the Highway 97 Bridge (RM 249) were completed by 1971. The channel dredging was done to fulfill the agreement with Reclamation to provide a channel capacity of 13,300 cfs to accommodate inflow from Reclamation canals. Up to 3.75 million cubic yards of material were removed and deposited on adjacent lands. Spoil material was spread across dispersed parcels bordering the river, and at least one portion of the river alignment was slightly smoothed. Sampling of the material prior to dredging indicated that most of the dredge spoil consisted of diatomite and sand (internal memorandum from J.L. Blackburn, Pacific Power & Light Company, to H.A. Hurbut, Jr., Klamath Falls, Oregon, dated August 15, 1966; attachment A-2 of PacifiCorp's response to AIR WQ-2 [c] dated May 16, 2005).

In March 2002, dredging was conducted in the Keno reservoir in front of the fish ladder exit to remove debris and sediment that were partially blocking the exit/water intake. About 17,000 cubic yards of material were removed via suction dredge, and the spoils were pumped across the Keno Park (the Keno Recreation Area) to a vacant lot about 600 feet to the southeast of Keno Park boat dock (letter from C. Scott, Licensing Project Manager, PacifiCorp, to the Commission, dated May 16, 2005, in response to AIR WQ-2 [c]). Material consisted of fine sediment and large wood debris. Permitting requirements did not require sediment testing, and no analyses of these sediments are available.

Sediment Transport

The transport of sediment within a river is a primary physical process, setting the stage for numerous ecological processes, including but not limited to, the recruitment of riparian vegetation, the scour and sorting of spawning gravels, and the creation and maintenance of complex instream habitat. Further, sediment transport (as modeled with numerical equations using selected parameters from field

[36]In this context, we conclude that PacifiCorp means that they used computer algorithms to filter the regularity and reflectivity, resulting in an unsupervised (meaning without human intervention) classification of bottom types. We conclude that they then used the coring data to establish which of the unsupervised classes correspond to specific bottom, resulting in a "supervised" interpretation of the hydroacoustic survey data.

work, explained below) is the backbone of PacifiCorp's sediment budget, upon which many geomorphological results and conclusions are based.

Data for bedload and suspended sediment sampling and observations on movement of tracer gravels are very limited for the project-affected reaches of the Klamath River. Bedload and suspended sediment transport sampling for project relicensing studies only occurred during 2003 at a site at the J.C. Boyle peaking reach upstream of the confluence of Shovel Creek. Peak flow during bedload sampling was 3,000 cfs, which is the flow release when both J.C. Boyle generators are operating. At 3,000 cfs, PacifiCorp measured a bedload transport rate of 1.04 tons per day, and at 2,800 cfs it was 0.6 ton per day; the suspended load transport rate was measured at 3,000 cfs as 256 tons per day. PacifiCorp concluded, based on these results, that the existing bed is not fully mobilized at 3,000 cfs.

In addition, tracer gravels (and surveyed cross sections and gravel location) were initially placed in the Klamath River in the following locations to document bed mobility during the 2002 snowmelt flow season: (1) upstream of the Shovel Creek confluence, (2) near R-Ranch downstream of Iron Gate dam, (3) above the Cottonwood Creek confluence, (4) at the I-5 rest area, and (5) in two tributaries (Shovel and Humbug creeks). Because flows were inadequate to produce movement of the tracer gravels in 2002, winter 2003, and spring 2003, new tracer gravel study sites were added to the J.C. Boyle bypassed reach near the emergency overflow spillway, in the J.C. Boyle peaking reach at the USGS gage, and in the Frain Ranch area of the J.C. Boyle reach. The Frain Ranch site included only unsurveyed tracer pockets, which were ostensibly sites where gravels were placed without a formal cross section to aid in recovery.

Tracer gravel transects were resurveyed in late June 2003 (table 3-4). Because of high flows at the time of survey, which made wading unsafe, only partial surveys were completed (data are available for three of nine sites). In several instances, tracer gravels were not recovered. During deployment, flows at the study sites were not large or long enough to completely mobilize the channel bed at the tracer transect locations. However, at the three resurveyed sites, some tracer gravels were mobilized. The bed elevation did not increase or decrease during the tracer studies, which is consistent with the tracer gravel results showing a lack of full bed mobility and the flow record illustrating that flows were below the discharge required for active channel bed conditions.

3.3.1.1.4 Fluvial Geomorphic Conditions for Riparian Vegetation

Fluvial processes can play a major role in generating floodplains of different heights suitable for establishing woody riparian species (Stromberg et al., 1991; Johnson, 1992; Scott et al., 1993; Rood and Mahoney, 2000). Flow regimes also are a potentially more important aspect governing the recruitment of riparian vegetation, regardless of geomorphic setting (Mahoney and Rood, 1998; Friedman and Auble, 1999). The following section presents the geomorphological foundation for our detailed discussion of riparian vegetation later in this EIS in section 3.3.4, *Terrestrial Resources*.

Fluvial geomorphic conditions affecting riparian vegetation recruitment and sustained growth include proper substrate and flow regime requirements, including (a) the timing, shape, and duration of descending limb of hydrograph, (b) the timing, magnitude, and duration of peak flows, and (c) the stage of base flows in relation to the recruitment surface.

Riparian trees, as pioneer species, are poor competitors that require bare, open sites with moist, fine-grained mineral soil with no organic duff for establishment. Recently scoured point bars or isolated patches of alluvial soil deposition along a river provide such conditions. Riparian seed viability is generally short, lasting about 2 to 4 weeks. Hence, these substrate conditions must coincide with both seed dispersal and a favorable rate of decline in soil moisture (water table elevation), discussed further in this section.

Table 3-4. Tracer gravel sites, deployment, and recovery. (Source: PacifiCorp, 2004f, as modified by staff)

Site	RM	Reach	Cross-section Tracer Location	Pocket Tracer Location	Deployment Date	Size of Tracers Deployed (mm); Number per Size Class Deployed (bold), if available	Size of Particles that Moved (bold); Were Unrecovered (*italics*), if available (mm)	High Flow During Tracer Deployment (cfs)
J.C. Boyle bypassed reach downstream of emergency overflow spillway	222.6	J.C. Boyle bypassed reach	Approx. 30 meters upstream of mid-channel bar	--	04/01/2003	Range = 41-115 mm 32-64 mm (**3**) 64-128 mm (**13**)	-- 32-64 mm (**2**) (*0*) 64-128 mm (**2**) (*4*)	1,700
			--	Upstream of island near the right bank of the main channel	04/01/2003	Range = 41-92 mm	N/A	1,700
			--	Midway along island near the right bank of the main channel	04/01/2003	Range = 47-91 mm	N/A	1,700
			--	Downstream end of island near the right bank of the main channel	04/01/2003	Range = 49-86 mm	N/A	1,700
J.C. Boyle peaking reach downstream of USGS gage	219.7	J.C. Boyle Peaking Reach	10 ft upstream of double snag and fallen trunk on right bank to	--	11/03/2002	Range = 45-96 mm 32-64 mm (**2**)	-- 32-64 mm (**0**) (*1*)	3,850

Site	RM	Reach	Cross-section Tracer Location	Pocket Tracer Location	Deployment Date	Size of Tracers Deployed (mm); Number per Size Class Deployed (bold), if available	Size of Particles that Moved (bold); Were Unrecovered (*italics*), if available (mm)	High Flow During Tracer Deployment (cfs)
			pine on left bank			64-128 mm (**12**)	64-128 mm (**0**) (*3*)	
J.C. Boyle peaking reach upstream of Shovel Creek confluence	206.5	J.C. Boyle Peaking Reach	Upstream of Shovel Creek confluence	--	2/14/02, additional traces placed on 04/26/2002	Range = 32-150 mm[a] 16-32 mm (**1**) 32-64 mm (**6**) 64-128 mm (**15**) 128-256 mm (**2**)	 16-32 mm (**0**) (*1*) 32-64 mm (**0**) (4) 64-128 mm (**1**) (*2*) 128-256 mm (**0**) (*0*)	3,988[b]

Notes: N/A = Not Available.

All resurvey of tracer gravels occurred on June 25, 2003. We assume that particles that were not recovered were either washed farther away than the zone re-surveyed (i.e., they were moved), or, alternatively they were not found at the time of resurvey because of survey error or the appearance of the tracer gravels was altered (via algae growth) such that they were no longer discernible as tracer gravels.

[a] While tables in the report results indicate the range as stated here, figure 3.7-57 in the report indicates that one smaller particle, in the medium gravel (8 to 16 mm) size class, was also deployed but did not move.

[b] Flow was estimated by adjusting flows measured at the J.C. Boyle USGS gage for accretion based on drainage area.

In terms of recruitment, spring peak flows and the descending limb of the annual hydrograph relative to seed dispersal are the most important aspects of riparian establishment. Riparian seedlings are intolerant of drought. The timing and rate of drop of the descending limb with respect to the elevation of the seed is important. If river water levels decline too rapidly, tree seedlings will not be able to grow roots fast enough to follow the coincident decline in soil moisture (caused by the drop in the water table[37]), and the seedling will die of desiccation. PacifiCorp assumed that coyote willow seed disperses in May and June and collected data accordingly. However, because only incidental observations of coyote willow seed dispersal were made in late May or early June 2002, these observations may not reflect the time period where the majority of willow seed dispersal occurs.

Although riparian seedlings are drought intolerant, they do tolerate flooding. This adaptation allows seedlings to handle short-duration flooding during the year of their establishment, or in the spring of subsequent years. However, despite this adaptation to inundation, seedlings can still be eliminated by physical scour or sediment deposition. Hence, establishment must occur at an elevation range high enough to escape peak flows that could scour or bury seedlings, but still low enough to maintain contact with a declining water table.

Link River

Because it is primarily a bedrock reach, channel morphology does not appear to be substantially controlled by riparian vegetation conditions. Likewise, the lack of substantial alluvial deposits also limits the recruitment of substantial amounts of riparian vegetation.

Keno Reach

The Keno reach also exhibits substantial bedrock control, and the influence of riparian vegetation on channel form is only slightly more substantial than in the Link River reach. The active channel in the Keno reach comprises a relatively large proportion of the valley bottom with relatively steep canyon walls extending up from the narrow floodplain. Therefore, surfaces for colonization by riparian vegetation (e.g., bars, terraces, islands) are relatively small and limited. There is generally a sharp demarcation between coarse substrates within the active channel and finer substrates on narrow terraces at the base of the canyon slopes.

J.C. Boyle Bypassed and Peaking Reaches

Geomorphic characteristics vary considerably throughout the J.C. Boyle bypassed and peaking reaches. Nonetheless, the relatively narrow band of riparian vegetation does not appear to substantially affect the formation and persistence of bedforms in the active channel or riparian zones. Even in alluvial portions of the reach downstream of the gorge, channel-forming processes do not currently appear to be strongly linked to riparian vegetation.

However, riparian vegetation on bars and channel margins of this reach appears to be affected by peaking operations. For instance, the sediment composition of most alluvial bars appears amenable to riparian vegetation recruitment and growth, but the bars are unvegetated to the margin of inundation during peaking. Similarly, vegetation is generally absent from channel margins within the same area of peaking inundation.

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[37]Although the elevation of the water table and soil moisture decline more slowly than do river levels, the stage (elevation) of the river is frequently gaged and provides readily accessible data. Further, although lagging behind the river to some degree, studies show that the decline of water table and soil moisture closely mirrors that of river stage.

Copco No. 2 Bypassed Reach

Because the base flow in this reach has been reduced to about 10 cfs (with occasional uncontrolled spill flows of thousands of cfs) for a long period of time, the river channel in the Copco No. 2 bypassed reach is characterized by very coarse cobble and boulder bars and substantial encroachment of riparian vegetation. The encroaching trees and their roots are holding cobbles and boulders in place, creating fossilized bars whereby the vegetation, channel position, and cobbles/boulders essentially do not move or substantively change, even with larger flows.

Iron Gate Dam Downstream to Seiad Valley

Throughout most of this reach, channel morphology and areas of riparian vegetation are influenced by local geologic control and, in some cases, by the presence of mine tailings. In addition, fluctuations in the annual hydrograph and decreased sediment supply also influence the recruitment and maintenance of riparian vegetation. As the lowest dam in the project, discharge from Iron Gate dam may influence recruitment for some distance downstream. In addition, the reach downstream of Iron Gate would theoretically face the largest sediment deficit of any reach related to the project.

PacifiCorp conducted studies of the reach downstream of Iron Gate dam to analyze the relationship between project flows and recruitment conditions. Studies included analysis of tree ages/recruitment date relative to flow records (from 1964 to 2001). PacifiCorp sampled the age of riparian trees using an increment borer at five vegetation transects where stage-discharge was modeled in the reach downstream of Iron Gate (the Iron Gate reach). The flow regime was evaluated with respect to tree age samples from water years 1964 to 2001.

3.3.1.2 Environmental Effects

3.3.1.2.1 Shoreline Erosion

There is little detailed information in the record regarding reservoir shoreline erosion. Information that is available is related to the role of shoreline erosion (compared to other factors such as livestock grazing and recreation) in the establishment of shoreline vegetation, and as related to cultural sites. PacifiCorp states that shoreline erosion is particularly apparent in the drawdown zones of J.C. Boyle, Copco, and Iron Gate reservoirs, and all three reservoir drawdown zones have extensive eroded areas. Several mechanisms contribute to the erosional loss of sediments in reservoir drawdown zones. Wave energy is undoubtedly the single largest factor moving sediments, with wave formation produced by wind and boat wakes. Wave erosion occurs mostly near the water's edge and, as the pool level fluctuates, this effect moves back and forth across the drawdown zone. This mechanism is most effective at removing fine sediments (that is, sands, silts, and clays), although larger waves associated with storms probably move gravel-sized particles as well. Erosion tends to have a winnowing effect, removing the finer sediments while leaving coarser gravel and cobbles. Ultimately, this coarser material can develop into an armored surface that is much less susceptible to erosion.

Shoreline erosion can be quantified by pedestalled trees and stumps along the reservoir margins, suggesting that at least 0.7 to 3.3 feet of sediment has eroded away in many places, with erosion most evident and pronounced on the shoreline of Copco reservoir. Wave-eroded cut banks between 10 and 15 feet in height exist on the shoreline of Copco reservoir. On J.C. Boyle and Iron Gate reservoirs, shoreline erosion is considerably less, but increases within about 1 mile upstream of the dams.

Issues related to erosion of riverine shorelines and cultural sites are documented in the license application based on observations during site visits made by PacifiCorp and tribal representatives. Tribal representatives expressed concern about the exposure and subsequent vandalism of sensitive cultural sites along the lower portion of Keno reservoir during drawdowns (the sites are inundated during normal project operations). Before Keno dam was constructed, this area was likely a patchwork of marsh and

upland. Keno dam inundated this area and eliminated a substantial portion of the emergent vegetation. Therefore, when drawdowns occur, flow over unvegetated fine sediments could disturb and expose sensitive cultural resources sites.

Tribal representatives also expressed concern about project-related erosion of a sensitive cultural site in the J.C. Boyle peaking reach near Frain Ranch. PacifiCorp staff observed erosion downstream of Iron Gate dam at the "Osburger" site during a site visit, where two historic houses were relocated from the town of Klamathon. The visit to the "Osburger" site was conducted at the request of Redding District Bureau of Land Management staff, who raised concerns to PacifiCorp regarding erosion at the site and possible links to project operations (letter from C. Scott, Project Manager, PacifiCorp Energy, to the Commission, December 1, 2006). The houses currently sit on a terrace approximately 30 feet above the water surface.[38]

PacifiCorp's proposed measures to address shoreline erosion are related to cultural sites, and are included in its HPMP discussed in section 3.3.9.2.2, *Management of Cultural Resources*. No other entities have made specific recommendations that pertain to controlling shoreline erosion.

Our Analysis

We observed steep, tall, eroded shorelines along the south shore of Copco reservoir during our site visits to the project area. It is unclear from the information available to us if erosion in this area has any detrimental effects on other resources. In the absence of such information, the need for remedial measures beyond those necessary to protect cultural sites has not been established.

The effects of erosion of riverine shoreline at cultural sites are site specific. The Keno reservoir reach of the Klamath River had a very low gradient before the project was established because of the flatness of the valley and the hydraulic control by the bedrock reef at Keno, so sediment transport dynamics were not changed substantially with the completion of Keno dam. However, because of the inundation associated with Keno dam, emergent wetland and riparian vegetation characteristics have changed, making cultural sites more visible when the reservoir level is low. Nonetheless, we conclude that exposure and vandalism of cultural sites at Keno reservoir is related to relatively infrequent reservoir drawdowns (every 2 years or so), not erosion. We discuss proposed measures to address these cultural sites during drawdown in section 3.3.9.2, *Cultural Resources*.

Erosion of the site in the J.C. Boyle peaking reach occurred during a flow that was well beyond the control of project facilities, within a back eddy at high river stage, and would probably have occurred even without the project. Although the project has altered sediment transport dynamics in this reach (see section 3.3.1.2.2, *Project Effects on Sediment Supply*), we conclude that erosion of this cultural site was driven mostly by the extreme flow event that occurred in 1997, and is not likely the direct result of project effects on geomorphology or sediment transport.

Erosion adjacent to the Osburger site downstream of Iron Gate dam does not appear to be directly linked to project effects on geomorphology and sediment transport. Evidence of erosion (and associated bank protection) was observed at the base of a steep slope below the houses and about 38 feet away from and 9.8 feet above the active channel edge and water surface elevation, respectively. The flow during the 1997 event that caused the erosion (20,500 cfs) was well above the range of project control. Although there has been an alteration to the river's capacity to supply and transport sediment in the reach downstream of Iron Gate dam, it appears to us that, similar to the site in the J.C. Boyle peaking reach, erosion at this site occurred in an area that could be a back eddy during high flows. Largely influenced by

[38]The flow at the time of PacifiCorp's site visit was 1,350 cfs, and at this flow there was no indication of actively eroding banks or bed mobilization.

natural topographic controls during high magnitude floods, existing local site conditions appear to be the primary factor in the erosion that threatened cultural resources in this area, not project operations.

3.3.1.2.2 Project Effects on Sediment Supply

Natural river reaches export fine and coarse sediment at rates approximately equal to sediment inputs. Although the amount of and mechanism for sediment storage within any particular river reach fluctuates from one year to the next, it sustains channel morphology and habitat attributes in a dynamic quasi-equilibrium[39] when averaged over the course of longer time periods such as a series of wet and dry years (on the order of 5 to 10 years or more).

The sediment that makes up the bed and banks of the Klamath River ranges in size from silt and sand to gravel, cobbles, and boulders with outcrops of bedrock. Since their construction, project dams have trapped most sediment that was previously delivered to downstream reaches and altered the flows necessary to transport sediment in reaches of the river. Together, these changes have altered natural sediment transport processes, reduced gravel bar and pocket gravel deposits, and reduced salmonid and lamprey spawning and rearing habitat. Additionally, project operations have increased sediment supply from point sources of erosion and fill encroachment on the river channel.

To evaluate sediment-related project effects, we used PacifiCorp's sediment budget[40] and hydraulic calculations as tools to assist in our evaluation of project effects. We also reviewed the record for information on point sources of sediment, canal failures, landslides, and other types of erosion, and made use of our site visit observations. We discuss sediment supply as it pertains to accumulation in project reservoirs in section 3.3.1.2.6, *Development Decommissioning and Dam Removal*.

Point-Sources of Erosion and Sediment Input in the J.C. Boyle Bypassed Reach

Maintaining the canal and roadway on the steep right bank[41] of the river canyon through the J.C. Boyle bypassed reach has resulted in the introduction of sidecast material to the river. This has narrowed the river channel in places, filled across the channel in one location, and caused erosion of the opposite bank. Rill and gully erosion of fill slopes below the road would likely continue if left unchecked. Landslides originating near the roadway in the downstream part of this reach (near Big Bend, downstream of the emergency spillway) are old and have largely stabilized.

With nearly 70,000 cubic yards of sediment eroded below it, the J.C. Boyle canal emergency spillway is the single largest point source of sediment in the project area. Currently, if the J.C. Boyle powerhouse trips offline, there is no bypass through the powerhouse to accommodate the water in the canal. Instead, it is spilled through the relatively low gradient concrete emergency spillway. Once water reaches the end of the concrete, it freefalls onto the canyon slope below, and flows to the river, eroding the hillslope in the process. The headward erosion of this hillslope may ultimately threaten the adjacent roadway, or even the canal itself. Given the nature of bypassed flows in the reach, sediment input from the spillway to the channel far outpaces the river's ability to transport it.

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[39]Dynamic quasi-equilibrium refers to the fact that sediment is dynamically transported through, or stored within, the channel, but channel morphology fluctuates only narrowly over time.

[40]Information on equations, actual spreadsheets, and other details of the sediment budget and associated hydraulic calculations are provided PacifiCorp (2004a) and PacifiCorp's AIR responses dated May 16, 2005, and December 16, 2005.

[41]Viewed from the perspective of looking downstream.

PacifiCorp proposes to install a synchronized bypass valve on each of the two Boyle powerhouse units to ensure ramping rates and minimum flows could be met if a unit trips offline. This would eliminate spill events at the emergency spillway.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp implement a flow continuation measure at the J.C. Boyle canal and powerhouse to provide a minimum of 48 hours of continuous flow under powerhouse shutdown conditions. The Hoopa Valley Tribe makes a similar recommendation, except the tribe recommends that the flow continuation device should provide "several hours of continuous flow" compared to the 48 hours recommended by Oregon Fish & Wildlife. Oregon Fish & Wildlife also recommends that PacifiCorp develop, in consultation with the agencies, a monitoring and maintenance plan that would eliminate or reduce failure of the water conveyance system and excess use of the emergency spillway. The monitoring component of the plan would include technology for early detection of waterway failure and protocols for stopping flows in the canal at the same time as restoring flows in the bypassed reach to maintain flows downstream of the powerhouse.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp develop a plan, in consultation with the agencies, that addresses procedures, environmental permits, and subsequent mitigation measures for any emergency spill, canal failure, or slope failure along the J.C. Boyle bypassed reach. The plan would include (1) implementation strategies for agency coordination, restoration actions, monitoring and evaluation, and potential mitigation measures; (2) provisions to ensure that the J.C. Boyle powerhouse has the capacity to maintain flow continuously for a minimum of 48 hours after an emergency shutdown; when powerhouse failure occurs, flow shall be released at the powerhouse for the duration of the failure; (3) provisions for implementing mitigation measures including revegetation of affected hillslope and riparian areas, monitoring surveys and photopoints for revegetation work, and evaluation and monitoring of affected reaches with channel transects and flow augmentation measures to eliminate channel impingements and to remove fine sediments in the spawning area downstream of the [spillway] failure; (4) provisions to prevent further erosion in the area below the emergency spillway; stabilization plans shall consider structural, vegetative, and flow strategy methods to halt erosion and restore the damaged hillslope, riparian, and channel areas to stop resource degradation and repair visual impacts; and a detailed monitoring strategy based on development of channel cross sections that is implemented annually for 10 years; and (5) site-specific restoration plans for the emergency spillway, and other canal and slope failures that include a map depicting the location of the proposed activity, designs for site stabilization, channel restoration, location of disposal sites, an erosion control plan, implementation and effectiveness monitoring designed to meet restoration criteria such as fish passage, channel bed and bank stability, and appropriate riparian vegetation, data collection, biological evaluation, or consultation in accordance with applicable Bureau of Land Management regulations. Oregon Fish & Wildlife also recommends that, within 3 years of license issuance, PacifiCorp restore the J.C. Boyle bypassed reach channel from damage due to the emergency spillway.

Oregon Fish & Wildlife recommends that, within 24 hours of an accidental spill or discharge from the waterway system or other event, PacifiCorp notify the Oregon Emergency Response System and provide a verbal report on location, duration, and effect on water quality and aquatic life. If PacifiCorp observes or suspects fish or wildlife or their habitat have been harmed, PacifiCorp would immediately (no later than next business day) notify and consult with the Oregon Fish & Wildlife's Klamath Falls office and the hydropower coordinator at the Prineville office. Additionally, PacifiCorp would file a written report with Oregon Fish & Wildlife, Oregon Environmental Quality, the Bureau of Land Management, FWS, and the Commission within 2 weeks of the event describing location, duration, and effect on water quality and aquatic life. Additionally, Oregon Fish & Wildlife recommends that PacifiCorp coordinate emergency response to spillway or water failure "or other events." Subsequent remediation planning and implementation would be initiated within 24 hours of the event. PacifiCorp would develop site-specific plans for remediation in consultation with Oregon Environmental Quality, FWS, the Bureau of Land Management, Oregon Division of State Lands, and Oregon Fish & Wildlife that would include immediate

steps to remedy the failure and bring the waterway back into operation, and timing and performance criteria to be met for completion of needed remediation. PacifiCorp would provide to the agencies by March 1 for the preceding calendar year, an annual report that describes each event and action taken to remediate effects, and the operation changes taken or proposed to reduce reoccurrence of the spill, discharge, or other event.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp develop in consultation with the agencies, an action plan that details protocols for assessing environmental damage caused by flume failure, spillway overflow at the forebay, and other events. The measure would include assessing and documenting immediate and long-term effects on water quality, fish and wildlife, riparian and aquatic organisms, and habitat. PacifiCorp would consult with fish agencies to develop a fish and wildlife habitat restoration plan that ensures compensation for short- and long-term loss of individuals and habitat caused by unanticipated project-related events that cause environmental damage. The plan would identify measures to meet Oregon Fish & Wildlife's objectives and standards for fish and wildlife, a schedule to accomplish these objectives and standards, and needs for additional studies.

Oregon Fish & Wildlife recommends that PacifiCorp consult with them, Oregon Parks & Rec, and other agencies 90 days before commencing any project-related land-clearing, land-disturbing, or spoil-producing activities, and use agency input to develop a comprehensive plan to control erosion, dust, and slope stability to minimize the quantity of sediment or other potential water pollutants resulting from project construction, spoil disposal, and project operation and maintenance. The plan would include detailed descriptions and functional design drawings of control measures, topographic map locations of all control measures, an implementation schedule, and details of monitoring and maintenance programs, and a schedule for periodically updating the plan. Similarly, the Bureau of Land Management's Condition 1-H specifies that PacifiCorp prepare a spoils disposal plan in consultation with the Bureau, prior to initiating any ground-disturbing activity on Bureau-managed lands. The plan would address disposal and storage of waste soil or rock material generated by road maintenance, slope failures, and construction projects and include provisions for (1) identifying and characterizing the nature of the spoils in accordance with applicable Bureau of Land Management regulations; (2) identifying sites for disposal and storage of spoils to prevent contamination of water by leachate and surface water runoff; and (3) developing and implementing stabilization, slope reconfiguration, erosion control, reclamation, and rehabilitation programs. PacifiCorp would modify the Bureau of Land Management's Condition 1-H to limit the scope of that condition to Bureau lands within the project boundary. PacifiCorp also adds the phrase "in its reasonable discretion" to the Bureau approval of the spoil disposal plan prior to submittal to the Commission.

The Bureau of Land Management's Condition 1-O specifies that PacifiCorp, within 1 year of license issuance, develop a standard operating procedures plan, in consultation with the Bureau, for emergencies to address procedures, environmental permits, and subsequent remediation for any project-related effects on Bureau-managed lands, including but not limited to, the emergency spillway and canal and slope failures. The plan would include implementation of strategies for agency coordination, restoration actions, monitoring and evaluation, and potential remediation measures. PacifiCorp would modify the Bureau's Condition 1-O by limiting the scope of that condition to Bureau-managed lands within the project boundary, and eliminating the required development of standard operating procedures that would specifically address emergency spillway and canal and slope failures.

Interior recommends that PacifiCorp, within 1 year of license issuance, would (1) develop, in consultation with the Bureau of Land Management, standard operating procedures for emergency situations that address emergency spillway and canal and slope failures and include implementation strategies for agency coordination, restoration actions, monitoring and evaluation, and potential mitigation measures; (2) ensure the J.C. Boyle powerhouse can maintain flow continuously for 48 hours during a powerhouse failure; (3) develop stabilization plans that consider structural, vegetative, and flow strategies to minimize erosion and restore damaged hillslopes, riparian areas, and stream channels to minimize

resource and visual impacts that could occur in the event of an emergency; (4) develop a plan, in consultation with the Bureau of Land Management, to restore the Klamath River from J.C. Boyle dam to Copco reservoir to compensate for effects from use of the J.C. Boyle emergency spillway; and (5) develop monitoring protocols based on channel cross sections to determine the effectiveness of restoration activities.

Interior recommends that PacifiCorp prepare site-specific remediation plans for the J.C. Boyle spillway and other canal and slope failures including (1) a map depicting the location of the proposed activity; (2) designs for site stabilization, channel restoration, location of disposal sites, and erosion control plan; (3) implementation and effectiveness monitoring of whether restoration objectives were met; (4) survey data, biological evaluations, or results from consultation for ground or habitat disturbing activities on Bureau of Land Management-managed land; and (5) an environmental analysis of the proposed action that meets NEPA requirements.

NMFS recommends that as part of a sediment augmentation plan (described in detail later in *Sediment Deficit in River Reaches Downstream of Project Dams*) PacifiCorp identify areas for removal of deposits of large debris. We presume that this is referring to the sediment deposition in the channel from the J.C. Boyle canal emergency spillway and road fill.

Our Analysis

Based on site conditions and past events, it is reasonable to expect rill and gully erosion, canal failures from rockfalls (such as the one in December 2005), and erosion at the emergency spillway to occur in the future. Because of the steep natural slope angles in the canyon, any remedial action to address road fill and sidecast material on the right bank of the canyon (which are inherently steeper than the natural slope angles, in order to fit in the space available) would require well-planned remediation and stabilization measures to maintain the road and canal without infringing on, or contributing sediment to, the channel.

The steepness and extent of the eroded slope at the emergency spillway would prove challenging to stabilize such that the slope would not erode further and would not contribute sediment to the river below. These difficulties, as well as the proximity of this erosion to the adjacent road and other infrastructure, and the effects of erosion on the river below are all strong reasons to address this site with a solution that eliminates the need to discharge water onto the slope.

The bypass system proposed by PacifiCorp and recommended by the agencies and tribes would alleviate the need to spill water through the J.C. Boyle canal emergency spillway. This would reduce the potential for greater erosion or mass failures of the slope that could jeopardize the road or other infrastructure. It would eliminate discharges of sediment from the eroded spillway slope into the bypassed reach, improving habitat and reducing turbidity, and would also reduce flow fluctuations in the bypassed and peaking reaches.

Oregon Fish & Wildlife and the Bureau of Land Management's measures would have PacifiCorp restore the J.C. Boyle bypassed reach channel from damage due to erosion of materials from the canal road cut and the emergency spillway and develop site-specific restoration plans to rehabilitate the site and prevent further erosion. Restoration would use structural, vegetative, and flow strategies to halt erosion and restore the damaged hillslope, riparian, and channel areas to stop resource degradation and repair visual effects. Monitoring would be undertaken so that actions would meet restoration criteria such as fish passage, channel bed and bank stability, and establishing appropriate riparian vegetation. The Bureau of Land Management specifies the development of standard operating procedures (including implementation strategies) for emergencies to address procedures, environmental permits, and subsequent measures for any project-related effects on Bureau-managed lands, including but not limited to, the emergency spillway and canal and slope failures. This is similar to Oregon Fish & Wildlife's recommendation that PacifiCorp develop an action plan that details protocols for assessing environmental

damage caused by flume failure, spillway overflow, and other events and would provide a consistent set of metrics from which to determine environmental effects. Both measures would assist in planning and prioritizing response actions.

Oregon Fish & Wildlife's recommendation that PacifiCorp consult with the appropriate agencies 90 days before commencing any project-related land-clearing, land-disturbing, or spoil-producing activities constitutes a practical planning and coordination mechanism to protect resources. We expect appropriate site-specific erosion and sedimentation control measures to be incorporated into the plans for such actions that would be submitted to the Commission for approval. Consultation with the agencies regarding protective measures that would be included in the final plans would enable any contractors who would implement the plans to understand agency concerns and plan their activities accordingly.

Similarly, Oregon Fish & Wildlife's recommendation to have PacifiCorp notify the Oregon Emergency Response System within 24 hours of an accidental spill or discharge and provide a written report to the appropriate agencies and the Commission within 2 weeks of the event would provide additional coordination and timely disclosure of events that could be potentially detrimental to natural resources. PacifiCorp's development of an appropriate emergency response and remediation plan (in consultation with the appropriate agencies) and implementation within 24 hours of the event would ensure timely and appropriate response to immediately remedy any spill or failure and bring the waterway back into operation. However, Oregon Fish & Wildlife's language requiring notification following accidental spills, discharges, or other events is so broadly worded that it is unclear what "other events" would require such notification of agencies and development of emergency response plans. Defining the specific types of events that would trigger agency notification would eliminate ambiguity regarding whether this emergency notification measure should be implemented. Annual reporting by PacifiCorp describing each event and action taken to address effects, and any operational changes taken or proposed to reduce reoccurrence of the spill, discharge, or other event would provide annual documentation of events and responses. Review of this annual report could support adaptive management whereby the standard operating procedures for emergency situations could be modified based on the experiences of past actions. Notification of the Commission concurrently with the agencies, and providing the Commission with the annual reports that document actions taken in response to accidental spills and discharges, would enable the Commission to determine if appropriate actions were taken and whether follow-up proactive actions may be necessary to prevent future inadvertent releases.

NMFS's recommendation for a plan that would include identification of areas for removal of deposits of large debris would be a useful mechanism to identify and prioritize for removal those areas of debris encroaching on the channel. As the recommendation is currently worded, such large debris could include naturally deposited debris that has no definable linkage to project operations. Defining the types of large debris that should be removed from the channel, and establishing a linkage of the debris removal to project operations, prior to developing detailed removal plans, would ensure debris is removed by the appropriate party.

3.3.1.2.3 Project Effects on Sediment Transport

Project dams interrupt the natural movement of sediment on the Klamath River, resulting in the potential for adverse effects on aquatic habitat (decreased spawning substrate and increased algal growth) and riparian vegetation. In response, PacifiCorp proposes and several agencies recommend supplementing the supply of sediment (especially gravel-sized material to enhance spawning habitat) in various river reaches. Also, because project effects on sediment transport likely extend downstream of the project boundary, determining the extent of these effects is important for developing the area of potential effects (APE) for cultural resources (see section 3.3.9, *Cultural Resources*) because it influences the distribution of riparian vegetation that is important for traditional tribal purposes.

Quantifying the rate of sediment transport, either at a single location for a specific discharge, or for part of an entire river system for an extended period of time, is inherently difficult. If at all possible, as suggested by Wilcock et al. (1996), estimates of bed mobility and bedload transport should be based on actual observations of bed movement. Although input data based on actual observations is low, we used hydraulic computations within microcomputer-based spreadsheet software (Microsoft Excel) to analyze project effects on sediment transport using data collected and assumptions made by PacifiCorp in its project license application. The spreadsheets were submitted by PacifiCorp (2005h; 2005j) in response to our AIR dated February 17, 2005, and in response to our correspondence with PacifiCorp dated November 10, 2005, and are the same base calculations that drive the sediment budget.[42] To supplement PacifiCorp's sediment budget, we also reviewed available aerial photographs and PacifiCorp's analysis on attributes of alluvial features downstream of Iron Gate dam.

Although the peer-reviewed mathematical equations that have been developed to quantify sediment transport are exacting in their execution, the outputs are also highly susceptible to variations in input parameters—several of which must be estimated or back-calculated in the absence of substantial empirical data collected in the field. Further, as noted by the American Society of Civil Engineers (Vanoni, 1975), different bedload transport formulas using the same hydraulic input data can yield results differing by several orders of magnitude. Thus, although useful, the analyses and results in this section should be understood to be approximations of complex physical processes. The results of our analyses are most useful in determining the relative (as opposed to absolute) level of change caused by the project, evaluating proposed environmental measures, and developing potential staff alternatives.

Threshold of Bed Mobility

In determining how much sediment is moved through a river, one of the first steps is determining the flow level at which certain sediment sizes are mobilized within the channel, or the threshold of mobility. Such analysis is also important in determining the adequacy of various flow levels to flush fine sediment and transport spawning gravels. Once threshold mobility analysis is completed, hydraulic parameters can be back-calculated and entered into sediment transport formulae, and ultimately those formulae can be used to drive a sediment budget, which is a conceptual model of how sediment is supplied to and transported through a river. Thus, the determination of mobility thresholds for certain particle sizes is an important first step in accurately portraying sediment movement in a river system.

The effects of the project on channel form, riparian vegetation, and aquatic habitats (notably salmonid spawning beds) are a function largely of the flows needed to mobilize the bed, the effects that project operations have on these flows, and the frequency and duration of bed mobility and sediment transport given the lack of sediment recruitment from above the dams. Of specific interest is the threshold above which a given particle size[43] of sediment becomes mobile. In estimating this threshold,[44] both the bed material composition and the hydrology must be considered. Accordingly, and as explained in detail in the license application, PacifiCorp used tracer gravel and bedload sampling data, along with

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[42]A sediment budget is a conceptual model that accounts for sediment production and routing from sources (hillslopes, streambanks, etc.) through reservoirs and river reaches in the project area. It provides a framework to describe the relative importance of various sediment sources within which the relative magnitude of project effects can be evaluated. We describe the sediment budget for the project area in greater detail in *Sediment Deficit in River Reaches Downstream of Project Dams*.

[43]Frequently the D_{50} (the median grain size in a given size distribution) particle size is used; we do so in our analyses.

[44]While the baseline for our analysis is the existing project, PacifiCorp conducted many of its analyses in terms of with- and without-project conditions, and we draw on its work to support our evaluations.

cross-sectional and long profile data for the representative reaches and hydrologic records, to evaluate flows needed to mobilize the bed and determine the frequency and duration of mobilization.[45] Additionally, we evaluate effects on particle mobilization under proposed flow conditions. We adopted PacifiCorp's assumptions that the D_{50} for the without-project condition (34.16 mm) is equal to the average D_{50} from the tributary delta surveys, and the D_{50} for the with-project condition is variable and is based on pebble counts and tracer gravel observations at PacifiCorp's study cross sections.[46]

The agencies have made a number of recommendations to address project effects on sediment transport and fine sediment flushing. NMFS recommends that, within 1 year of license issuance, PacifiCorp, in consultation with the agencies, assess flows needed to transport gravels and maintain holding habitat. Oregon Fish & Wildlife recommends that, at least once a year between February 1 and April 15, no water be diverted to the J.C. Boyle and Copco No. 2 powerhouses when inflow to J.C. Boyle reservoir (including Spencer Creek) exceeds 3,300 cfs, and that this diversion cessation be maintained for at least 7 full days. This high flow is not prescribed annually, but rather is triggered by an inflow to the J.C. Boyle reservoir of more than 3,300 cfs. The Bureau of Land Management specifies the above seasonal high flow regime for the J.C. Boyle bypassed reach, and FWS recommends that at least once yearly between February 1 and April 15, PacifiCorp not divert water to the Copco No. 2 powerhouse when inflow to Copco reservoir first exceeds 3,300 cfs; cessation of diversion would be maintained for at least 7 full days.

All other flow-related recommendations in this proceeding are for lower, base-flow discharges intended to enhance aquatic habitat (discussed in section 3.3.3.2, *Aquatic Resources*); those flows would not be capable of mobilizing substantial sizes or quantities of sediment.

Our Analysis

Even though a given flow reaches the threshold of mobility for the D_{50} particle, or even fully mobilizes that particle size, the coarser component of the bed may not have initiated motion. Despite this, we assume that mobilization of the D_{50} particle approximates the flow that mobilizes the bed at a particular location, allowing us to analyze seasonal high flow events relative to their potential efficacy. Table 3-5 summarizes PacifiCorp's calculated flows at the threshold of bed mobility for each study cross section. PacifiCorp calculated the frequency of bed mobility for each study reach using with- and without-project hydrology (mean daily flow data from 1968 to 2001); table 3-6 shows these results. Those results indicate that, except for the Link River and Keno reaches, the project consistently increases the estimated discharge required to mobilize the bed. Project operations reduce the frequency of bed-mobilizing events from roughly an annual or semi-annual basis to about two times less frequent. This indicates that, without project operations, spawning gravels would be more-frequently mobilized, flushed, and replenished from upstream. In the river reaches immediately downstream of Iron Gate dam, results indicate that the bed is only mobilized on average every 4 to 9 years. More-frequent seasonal high flow events would refresh spawning gravels and disperse sediment across the channel (and potentially onto the floodplain, depending on the magnitude of the flow), benefiting aquatic and riparian habitats.

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[45]An identified bias of this work was the selection of gravel sites in the steepest part of the J.C. Boyle bypassed reach and in the flattest part of the peaking reach. This likely produced both under- and overestimates. Additionally, as described in section 3.3.1.1.3, data for bedload and suspended sediment transport sampling for project relicensing studies occurred in 2003 at a single site at the J.C. Boyle peaking reach upstream of the confluence of Shovel Creek.

[46]The median grain sizes used for the with-project condition are contained in table 6.7-13 of PacifiCorp (2004a).

Table 3-5. Flow at threshold of mobility for with- and without-project conditions. (Source: PacifiCorp, 2004a)

Study Reach	Cross Section	With-Project Flow at Threshold of Mobility (cfs)	Approximate Return Interval (years)	Without-Project Flow at Threshold of Mobility (cfs)	Approximate Return Interval (years)
Link River Geomorphic Reach					
Link River	RM 254	1,346	0.7	Same	0.7
	RM 253.9	1,191	0.7	Same	0.7
	Study Reach Average	1,268	0.7	Same	0.7
Keno Geomorphic Reach					
Keno	RM 232.4	3,310	1.7	Same	1.7
	RM 232.1	4,706	2.7	Same	2.7
	RM 231.9	3,225	1.6	Same	1.6
	Study Reach Average	3,747	2.0	Same	2.0
J.C. Boyle Bypassed Geomorphic Reach					
J.C. Boyle	RM 223.5	2,251	1.0	1,968	0.9
Bypass	RM 223.3	1,921	0.9	1,604	0.9
Upstream of	RM 223.25	181	0.6	112	0.6
Blowout	Study Reach Average	1,451	0.8	1,228	0.8
J.C. Boyle	RM 222.55	4,188	1.7	2,323	1.0
Bypass	RM 222.4	3,828	1.5	1,432	0.8
Downstream	RM 222.3	3,548	1.4	1,577	0.9
of Blowout	Study Reach Average	3,855	1.5	1,778	0.9
J.C. Boyle Peaking USGS Gage/Frain Ranch Geomorphic Reach					
J.C. Boyle	RM 219.9	4,489	1.8	2,232	1.0
Peaking at	RM 219.7	4,293	1.7	2,449	1.1
USGS Gage	Study Reach Average	4,391	1.8	2,340	1.1
J.C. Boyle	RM 217.8	46,497	n/a	2,922	1.2
Peaking at	RM 217.5	40,946	n/a	5,935	2.6
Bureau of	RM 217.2	47,164	n/a	5,502	2.4
Land	Study Reach Average	44,869	n/a	4,786	2.1
Management Campground					
J.C. Boyle Peaking at Gorge Geomorphic Reach					
J.C. Boyle	RM 214.4	3,410	1.4	3,186	1.3
Peaking at	Study Reach Average	3,410	1.4	3,186	1.3
Gorge					
J.C. Boyle Peaking Near Shovel Creek Geomorphic Reach					
J.C. Boyle	RM 206.5	4,849	2.0	1,931	0.9
Peaking near	RM 206.4	4,320	1.7	1,753	0.9
Shovel Creek	RM 206.2	4,887	2.0	164	0.6
Confluence	Study Reach Average	4,685	1.9	1,283	0.8
Copco No. 2 Geomorphic Reach					
Copco No. 2	RM 197.7	1,801	<1	167	<1
	RM 197.66	2,505	<1	255	<1
	Study Reach Average	2,153	<1	211	<1
Downstream of Iron Gate Dam to Cottonwood Creek Geomorphic Reach					
Downstream	RM189.7	27,655	24.4	3,429	1.5
of Iron Gate	RM 189.6	8,558	2.6	4,542	1.7
dam to USGS	RM 189.5	11,050	3.5	4,365	1.6
Fish Hatchery	RM 189.45	12,504	4.2	5,224	1.8
Gage	Study Reach Average	14,942	8.7	4,390	1.7

Study Reach	Cross Section	With-Project Flow at Threshold of Mobility (cfs)	Approximate Return Interval (years)	Without-Project Flow at Threshold of Mobility (cfs)	Approximate Return Interval (years)
Downstream of Iron Gate dam at R-Ranch	RM 187	9,731	3.0	6,639	2.1
	RM 186.7	12,403	4.1	6,201	2.0
	RM 186.6	14,408	5.2	11,450	3.7
	Study Reach Average	12,181	4.1	8,096	2.6
Cottonwood Creek to Scott River Geomorphic Reach					
Downstream of Iron Gate dam at I-5 Rest Area	RM 179.1	6,348	2.0	3,769	1.5
	Study Reach Average	6,348	2.0	3,769	1.5
Downstream of Iron Gate dam at Tree of Heaven Campground	RM 172.4	11,819	3.9	5,891	1.9
	RM 172.2	14,172	5.1	6,627	2.1
	RM 171.9	25,994	20.1	13,654	4.8
	Study Reach Average	17,329	9.7	8,724	2.9
Downstream of Scott River Geomorphic Reach					
Downstream of Iron Gate dam at Seiad Valley-Hardy Site	RM 131.55	389,623	n/a	210,470	n/a
	Study Reach Average	389,623	n/a	210,470	n/a
Downstream of Iron Gate dam at Seiad Valley USGS Gage	RM 128.5	67,913	10	26,658	2.9
	Study Reach Average	67,913	10	26,658	2.9

Table 3-6. Frequency when flows exceeded the threshold of mobility. (Source: PacifiCorp, 2004a)

		Percent of Period of Record Flows Exceeded Threshold of Mobility		
Study Reach	Cross Section	With Project	Without Project	Ratio (With Project to Without Project)
Link River Geomorphic Reach				
Link River	RM 254	32	32	1
	RM 253.9	36	36	1
	Study Reach Average	33	33	1
Keno Geomorphic Reach				
Keno Reach	RM 232.4	11	11	1
	RM 232.1	6	6	1
	RM 231.9	11	11	1
	Study Reach Average	9	9	1
J.C. Boyle Bypass Geomorphic Reach				
J.C. Boyle Bypass Upstream of Blowout	RM 223.5	6	30	0.19
	RM 223.5	7	34	0.20
	RM 223.25	16	100	0.16
	Study Reach Average	9	46	0.19
J.C. Boyle Bypass Downstream of Blowout	RM 222.55	2	28	0.07
	RM 222.4	3	46	0.06
	RM 222.3	3	40	0.08
	Study Reach Average	3	35	0.07
J.C. Boyle Peaking Geomorphic Reach				
J.C. Boyle Peaking at USGS Gage	RM 219.9	7	29	0.23
	RM 219.7	7	26	0.28
	Study Reach Average	7	27	0.26

Study Reach	Cross Section	Percent of Period of Record Flows Exceeded Threshold of Mobility: With Project	Without Project	Ratio (With Project to Without Project)
J.C. Boyle Peaking at the Bureau of Land Management Campground	RM 21738	0	16	0.00
	RM 217.5	0	3	0.00
	RM 217.2	0	4	0.00
	Study Reach Average	0	6	0.00
J.C. Boyle Peaking at Gorge Geomorphic Reach				
J.C. Boyle Peaking at Gorge	RM 214.4	12	13	0.91
	Study Reach Average	12	13	0.91
J.C. Boyle Peaking Near Shovel Creek Geomorphic Reach				
J.C. Boyle Peaking near Shovel Creek Confluence	RM 206.5	7	33	0.20
	RM 206.4	9	37	0.23
	RM 206.2	6	100	0.06
	Study Reach Average	7	54	0.13
Copco No. 2 Geomorphic Reach				
Copco No. 2	RM 197.7	7	100	0.07
	RM 197.66	5	100	0.05
	Study Reach Average	6	100	0.06
Downstream of Iron Gate dam to Cottonwood Creek Geomorphic Reach				
Downstream of Iron Gate dam at USGS Fish Hatchery Gage	RM 189.7	0	16	0.00
	RM 189.6	1	10	0.13
	RM 189.5	0.2	10	0.02
	RM 189.45	0.1	7	0.01
	Study Reach Average	0.3	11	0.04
Downstream of Iron Gate dam at R-Ranch	RM 187	1	4	0.18
	RM 186.7	0.1	5	0.02
	RM 186.6	0.03	0.2	0.16
	Study Reach Average	0.4	3	0.12
Cottonwood Creek to Scott River Geomorphic Reach				
Downstream of Iron Gate dam at I-5 Rest Area	RM 179.1	6	17	0.33
	Study Reach Average	6	17	0.33
Downstream of Iron Gate dam at Tree of Heaven Campground	RM 172.4	1	9	0.08
	RM172.2	0.3	6	0.04
	RM 171.9	0.02	0.3	0.08
	Study Reach Average	0.4	5	0.07
Downstream of Scott River Geomorphic Reach				
Downstream of Iron Gate dam at Seiad Valley-Hardy Site	RM 131.55	0	0	0
	Study Reach Average	0	0	0
Downstream of Iron Gate dam at Seiad Valley USGS Gage	RM 128.5	0.02	0.2	0.1
	Study Reach Average	0.02	0.2	0.1

The ratio of with-project to without-project frequencies illustrates the degree of alteration caused by the project. A high ratio (approaching 1.0) indicates that the frequency of mobilization under current conditions closely matches that of without-project conditions. Low (or zero) ratio values indicate that rarely (or never) do existing conditions match the frequency of without-project conditions. This can be the result of two things: either the flows are not high enough to exceed the threshold of mobility for sediment that is essentially similar to without-project size distribution, or the existing with-project bed condition (as characterized by the pebble counts data and D_{50} used in the analysis) has become too coarse to be mobilized by the current flow regime.

The deployment and monitoring of tracer gravels provides empirical data on which flows are capable of initiating particle movement, which assists in determining the effects of proposed seasonal high flow events. All of PacifiCorp's tracer gravel work was completed within the J.C. Boyle bypassed reach (one site) or the J.C. Boyle peaking reach (two sites). During the study, the site in the bypassed

reach downstream of the emergency spillway experienced a peak flow of 1,700 cfs and had 4 tracers out of 16 total tracers undergo some movement. All tracers at the site ranged from 32 to 128 mm, and 2 tracers each from both the 32 to 64 mm class and the 64 to 128 mm class moved. Because 2 tracers in the 64 to 128 mm class moved at flows below 3,800 cfs, the calculated threshold estimate of roughly 3,800 cfs needed to move a 128 mm particle is probably an overestimate, and lower flows are likely capable of mobilizing spawning-sized sediment in this reach. Overall, these tracer gravel results and the results from the other sites, suggest that the reliability of PacifiCorp's hydraulic threshold of mobility calculations is variable when compared to empirical data.

The estimates of discharge at the threshold of bed mobility have substantial uncertainty. Sources of uncertainty include the Shield's numbers (a dimensionless value of critical shear stress) used in the calculations for each study reach cross section, which PacifiCorp based on a limited set of tracer gravel movement observations. PacifiCorp calibrated the Shield's number with the tracer observations at just one study reach (J.C. Boyle peaking reach at the USGS gage). PacifiCorp applied this value to all study sites for the with-project condition analysis. For the without-project estimates, PacifiCorp used an experimentally derived Shield's number obtained from studies on gravel-bed systems. Aside from arbitrary judgment, we have no further basis or available information upon which to quantitatively modify these parameters. Further, the Manning's roughness coefficient that PacifiCorp used to estimate the discharge associated with the depth of flow at the threshold of bed mobility was also calibrated at a limited number of study reach cross sections and then applied to the remaining study sites. Again, we have no data upon which to propose an alteration.

The NMFS recommendation to assess flows needed to transport gravels and maintain holding habitat would provide the information necessary to implement any sediment augmentation measures. The resource and land management agency measure to suspend diversion of water to the J.C. Boyle and, in the case of the resource agencies, Copco No. 2 powerhouses for 7 full days one time a year between February 1 and April 15 when inflow to the J.C. Boyle reservoir exceeds a 3,300 cfs trigger, would ostensibly provide flows through the J.C. Boyle and Copco No. 2 bypassed reaches of the Klamath River at levels that could mobilize sediment of existing particle sizes. The magnitude and duration of flows that actually exceed the threshold of mobility would essentially be controlled by upstream outflow from Upper Klamath Lake. Although natural flows vary leaving the lake, and it is difficult to precisely quantify future flows and effects on sediment mobilization, we can make some comparison to past flow records. Between 1990 and 2005, inflows to J.C. Boyle reservoir exceeding about 3,300 cfs occurred 8 times, a frequency of about once every 2 years. As figure 3-3 shows, the NMFS, Bureau of Land Management, and Oregon Fish & Wildlife seasonal high flow measure would have resulted in flows released at J.C. Boyle dam to the bypassed reach above 3,300 cfs an additional 2 years as compared to 6 years under the present flow regime. During average to low flow water years (such as 2000 and 2003), this measure would have resulted in flows in excess of 3,300 cfs in the bypassed reach, substantially above the historical flows as compared to wetter years such as 1999, when flows in excess of 3,300 cfs were common. Table 3-7 shows the number of days flows in excess of 3,300 cfs occurred in historical conditions, what would occur under the NMFS, Bureau of Land Management, and Oregon Fish & Wildlife seasonal high flow measure, and the average flow value for those days above 3,300 cfs.

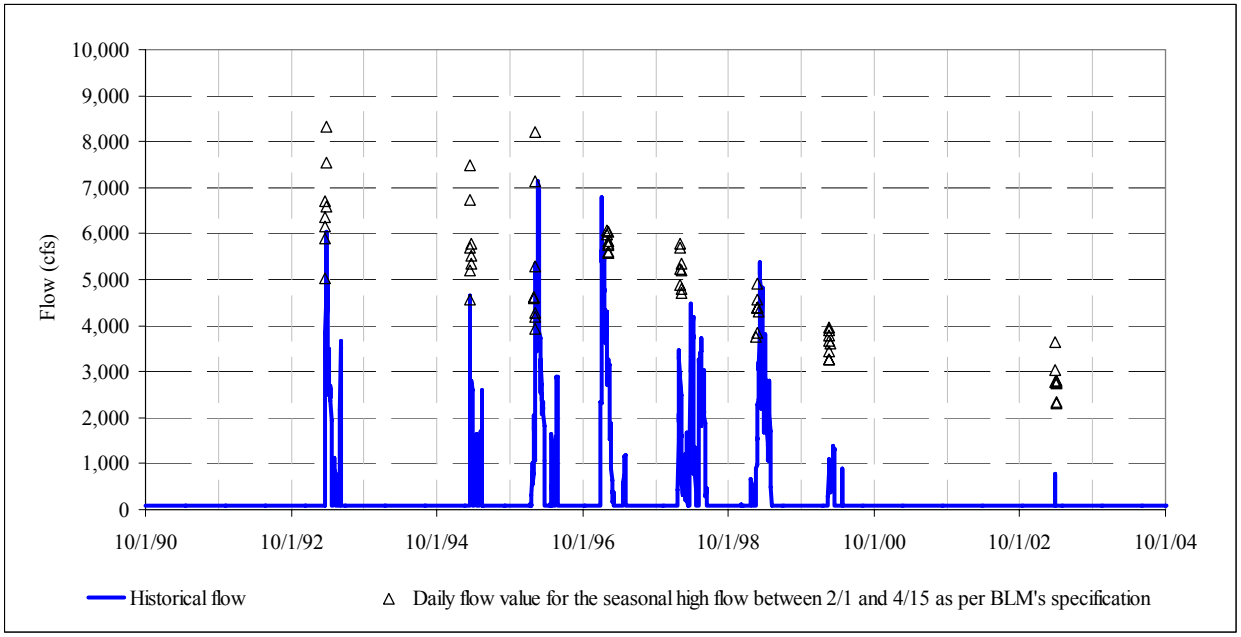

Figure 3-3. Flows released from J.C. Boyle dam to the bypassed reach under historical conditions and flows specified in the NMFS, Bureau of Land Management, and Oregon Fish & Wildlife seasonal high flow measure. (Source: USGS, 2006a, as modified by staff)

Table 3-7. Flow summary for historical conditions for releases from J.C. Boyle dam to the bypassed reach and the flows specified by the NMFS, Bureau of Land Management, and Oregon Fish & Wildlife seasonal high flow measure. (Source: USGS, 2006a, as modified by staff)

	Number of Days with the Average Daily Flow above 3,300 cfs		**Average Daily Flow (cfs)**	
Water Year	**Historical and Bureau's minimum flow specification[a]**	**Bureau's minimum flow and the 7 day seasonally high flow release specification**	**For the Historical and Bureau minimum flow specification for days in excess of 3,300 cfs**	**For the 7 day Seasonal High Release**
1991	0	0	-	-
1992	0	0	-	-
1993	18	20	4,321	6,576
1994	0	0	-	-
1995	2	7	4,255	5,790
1996	24	29	4,808	5,280
1997	29	36[b]	4,807	5,834
1998	17	24	3,770	5,207
1999	16	23	4,477	4,320
2000	0	7	-	3,617

Water Year	Number of Days with the Average Daily Flow above 3,300 cfs		Average Daily Flow (cfs)	
	Historical and Bureau's minimum flow specification[a]	Bureau's minimum flow and the 7 day seasonally high flow release specification	For the Historical and Bureau minimum flow specification for days in excess of 3,300 cfs	For the 7 day Seasonal High Release
2001	0	0	-	-
2002	0	0	-	-
2003	0	7	-	2,806
2004	0	0	-	-

[a] The combination of the minimum flow equation specified by the Bureau of Land Management and the hydraulic capacity of the powerhouse results in equal flow rates in the bypassed reach when inflows to the reservoir exceed 4,700 cfs for both historical and during operation governed by the minimum flows specified by the Bureau of Land Management.

[b] Flows in excess of 3,300 cfs occurred in the bypassed reach during January 1997, as shown in figure 3-3.

Flows that would be released with implementation of a seasonal high flow measure would increase the frequency of flows 3,300 cfs or greater through the bypassed reach, all of which would be capable of mobilizing the D_{50} particle size at the majority of the study cross section sites in the reach and would increase the frequency of flows capable of cleansing existing or augmented spawning gravels (should they be introduced under a new license). Although the benefits in the confined J.C. Boyle bypassed reach might be relatively small, seasonal high flow releases could encourage desirable woody riparian vegetation and potentially scour and discourage more invasive vegetation types such as reed canarygrass. Sediment particles larger and smaller than gravel, that may be introduced to the bypassed reach pursuant to the sediment augmentation measure specified in the Bureau of Land Management's modified 4(e) condition, would be distributed to downstream locations more effectively with higher and more frequent flows to the bypassed reach, which could enhance geomorphological benefits in the bypassed reach and in the peaking reach.

Our analysis also points out the need to consider flexibility in the approach to seasonal high flow releases. For example, during 1997, high flows occurred in the bypassed reach that averaged 4,808 cfs over 29 days. Most of these high flows occurred during January, prior to the February 1 onset of the window for releasing seasonal high flows. The incremental benefit of shutting down the powerhouse to provide an additional 7 days of bypassed reach flows over 3,300 cfs would be marginal, at best. The incremental benefits of a seasonal high flow release during years similar to 1999, when average spillage flows under historic conditions would be comparable to flows during a 7 day powerhouse shutdown would also be minimal. However, during years such as 1993, 1995, 2000 and 2003, the benefits of a seasonal high flow event would be substantially greater than would occur during years such as 1997 and 1999 because of the greater magnitude of the release flow relative to what would have occurred. Addressing circumstances in a project operations management plan that would warrant foregoing a seasonal high flow event even if the 3,300 cfs inflow trigger during the designated time frame is met, could avoid making releases that would provide little if any environmental benefit.

Sediment Deficit in River Reaches Downstream of Project Dams

Project dams prevent the downstream transport of sediment, which may result in a diminished supply of spawning gravel and other altered geomorphological processes (including sand and silt starvation) that may influence aquatic habitat and adversely influence the establishment of riparian vegetation. Measures designed to address these effects focus on assessing the extent of project effects and supplementing the sediment supply downstream of project dams. Also, The California Coastal

Commission (in a letter dated July 22, 2004), requested that we evaluate how project dams may be affecting the movement of sediment to the coastal littoral zone. Similarly, the Humboldt County Board of Supervisors (in a letter dated June 22, 2004) asked that we consider sediment supply beyond the Klamath River (i.e., down the coast), and Interior (in a letter dated July 22, 2004) asked that we consider the effects of project operations on coastal resources at Redwood National and State Parks.

PacifiCorp proposes to place about 100 to 200 cubic yards of spawning gravel in the upper end of the J.C. Boyle bypassed reach and 1,800 to 3,500 cubic yards downstream of Iron Gate dam and upstream of the Shasta River confluence, and to monitor the sediment augmentation efforts. In its July 21, 2004, response to our request that PacifiCorp provide specific costs for its proposed environmental measures, PacifiCorp indicated that sediment augmentation would occur over a 30-year period; however, from the description in the license application we interpreted this measure to be a one time deposition in the draft EIS. In its comments on the draft EIS (PacifiCorp, 2006x), PacifiCorp clarified that its sediment augmentation measure actually calls for recurring placement. It clarified that the volume and frequencies of recurring sediment augmentation would be based on monitoring of the initial gravel placements and that its assessment of bed mobilizing flow recurrence intervals suggests that recurrence of sediment augmentation may have to occur about every 3 years.

The Bureau of Land Management specifies in modified 4(e) measure 4 that PacifiCorp, within 1 year of license issuance, develop a sediment management plan for J.C. Boyle bypassed and peaking reaches in consultation with the Bureau, designed to increase channel complexity and availability of spawning habitat for resident and anadromous fish. The plan would include the following components: (1) a description of how channel complexity would be provided such that variation in channel depth, velocity, substrate, cover, and temperature at all flows is restored; (2) the quantity of sediment would be developed such that objectives outlined in the modified condition are met; (3) timing of gravel added, based on estimates of ongoing reductions in sediment supply because of J.C. Boyle dam; (4) methods of sediment augmentation, including passive augmentation at a logistically convenient location, allowing high flows to distribute over time; placement of discrete quantities of gravel in locations, usually riffles, where they are expected to provide the most benefit, based on hydrologic and biologic considerations; and modeling of reach characteristics to determine sediment augmentation; (5) objectives describing how the plan satisfies the Bureau's Management Plan direction; and (6) evaluation procedures. The modified measure adopts a large initial augmentation, to mitigate for long-term reduction below project dams, followed by recurring smaller augmentation amounts. The Bureau's modified condition also refers to "sediment storage" and "sediment storage potential" of the reach in response to the idea that a large initial augmentation could be focused on filling the in-channel storage sites that have sustained the long-term reduction of sediment because of the project. With this approach, subsequent sediment augmentation could be adaptively managed more effectively in future years, with annual sediment augmentation amounts being responsive to the flows that the reach receives in any given year. Estimates of bed-stored sediment potential exist, but estimates for bar top and channel margin trapping of sediment remain to be developed. Annual sediment augmentation amounts would be determined in the sediment management plan as stipulated between the Bureau of Land Management and PacifiCorp and would be based upon meeting the overall objectives of the plan. The program would be adaptively implemented over the term of the license, with implementation during years 1 through 3, monitoring and evaluation during years 1 through 7, and adaptation during years 7 through 9 (which would be used to modify the plan for the next 10 year sediment management cycle).

The Bureau of Land Management specifies that PacifiCorp submit to the Bureau and the Commission, within 6 months of the end of each implementation and monitoring year, an annual report on the activities of the sediment management program during the previous year, including the quantities of gravel added, methods used, and monitoring data. PacifiCorp would consult with the Bureau regarding any proposed changes to implementation and monitoring, and implement the changes after Commission approval. PacifiCorp would submit to the Bureau and the Commission in the 7th year, a comprehensive

monitoring report of the monitoring data from the previous 6 years, consult with the Bureau regarding any necessary changes to the sediment management plan, and implement any proposed changes after Commission approval.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp develop and submit to the Commission for approval a sediment and gravel resource management plan in consultation with Oregon Fish & Wildlife (allowing 60 days for review and comment)and other state, federal, and tribal agencies. PacifiCorp would update the plan every 5 years in consultation with the agencies. PacifiCorp would submit annual reports to the Commission and the agencies that include the annual work plan for the upcoming year and a report with narrative and graphs summarizing an annual compilation of activities associated with protection and restoration measures and associated monitoring that would be implemented to mitigate for the lack of sediment transport through project reaches to riverine habitat. Oregon Fish & Wildlife also recommends that, within 2 years of license issuance and after consultation with agencies, PacifiCorp file with the Commission a gravel and sediment plan that identifies measures that would be implemented to provide for the restoration of spawning habitat below each project dam. The plan would include provisions to map and characterize the character and distribution of gravels within project reaches, the approximate area of suitable spawning habitat, and the depths and velocities of flows required for each mapped gravel deposit to assess suitability of gravels as spawning habitat. Oregon Fish & Wildlife recommends that within 3 years of license issuance and in consultation with resource agencies PacifiCorp develop and implement recommendations for sediment management for each project-affected reach including the approximate size and volume of gravels needed to compensate for project effects and locations and timing for gravel introduction. Oregon Fish & Wildlife recommends that, upon placement of gravel in project reaches, PacifiCorp develop and implement a monitoring program to assess distribution and use of introduced gravels under project operations. If monitoring shows that the plan does not achieve plan objectives, PacifiCorp would revise it in consultation with the resource agencies. Cal Fish & Game and the Hoopa Valley Tribe recommend measures that are essentially identical to the aforementioned Oregon Fish & Wildlife measures.

NMFS recommends that, within 1 year of license issuance and in consultation with the agencies, PacifiCorp develop a sediment augmentation plan for project reaches and the Klamath River downstream of Iron Gate dam. The plan would include (1) identification of priority spawning and holding reaches; (2) assessment of flows needed to transport gravels and maintain holding habitat (pools); (3) identification of areas for removal of deposits of large debris; and (4) identification of priority areas for sediment augmentation, volumes of gravel, and flows to implement deposition of gravel in target areas and schedule for periodic replenishment of gravels. The plan would be implemented within 3 years of license issuance, results monitored in consultation with agencies, and reviewed at least every 5 years for the term of the license to facilitate adaptive management. FWS recommends a measure that is essentially identical to the aforementioned NMFS measure.

Siskiyou County recommends that PacifiCorp expend funds necessary to remove and manage sediment in refuge areas along the Klamath River below Iron Gate dam and to remove any existing sediment barriers to fish passage in the lower Klamath River.

Our Analysis

Our assessment of measures to augment sediment supply (particularly spawning gravel) downstream of project dams includes review and assessment of PacifiCorp's study results and information on the record, and also entails determining the downstream extent of project-induced sediment deficit, which influences colonization by riparian vegetation of importance to Native Americans, and is therefore a key factor in our determination of an appropriate APE for cultural resources. We assess the sediment deficit in river reaches downstream of project dams using the bedload sediment budget

developed[47] by PacifiCorp. The focus of the sediment budget analysis was the coarser (i.e., bedload) components, because these would be more strongly influenced by project effects, and because they are especially important for channel form and salmonid habitat (e.g., spawning gravels). Using estimates of the flows at which various sizes of sediment are mobilized, PacifiCorp used the Meyer-Peter Muller equation in its sediment budget to calculate the bedload transport rate for each cross section in each study reach for both existing conditions and without-project hydrology and bed material composition. Annual transport capacities were generated using daily hydrology data for water years 1968 to 2001.

The sediment budget results are most useful in assessing relative effects in different project reaches. The average annual theoretical transport capacity is used in the calculation of outputs and changes in storage because PacifiCorp did not conduct any direct bedload sediment transport sampling at appropriate[48] flows. Actual data collection to calibrate the estimates of annual transport capacity would greatly improve the accuracy of the sediment budget. PacifiCorp notes that, because of this, and for other reasons, the uncertainty associated with this sediment budget is likely high. We concur, but nonetheless conclude that the sediment budget still provides a useful framework for assessing the relative extent of project effects on sediment supply, transport, and storage. One fact that supports this notion is that the theoretical calculations show that in most reaches, transport capacity far exceeds supply on a long-term basis, so the river is supply-limited (yet frequently starved of sediment by project dams) through much of the project area. At some point downstream of Iron Gate dam, the river's sediment supply begins to exceed transport capacity; we examine this in greater detail later in this section.

We are unaware of any project-related fish passage barriers in the Klamath River that are caused by sediment. All the sediment trapped in project reservoirs is eliminated as a source of supply to downstream reaches, and sediment starvation (a sediment deficit) is a direct project effect on the geomorphology of the Klamath River. High spring flows diminish below Iron Gate dam as a result of Reclamation filling Upper Klamath Lake; this could cause sediment barriers to be established. As such, Siskiyou County's recommended measure seems misplaced.

PacifiCorp provided revised sediment budget results (PacifiCorp, 2005h) in response to our AIR dated February 17, 2005. Those results detail PacifiCorp's assessment of the sediment deficit in various project reaches (table 3-8). Their results indicate that the project-induced sediment deficit on the Klamath River would be eliminated by incoming sediment at the location of the Cottonwood Creek confluence.

In general, because of limited available data, we do not disagree with the approach of, or results generated by, PacifiCorp for reaches upstream of Iron Gate reservoir. However, from that point downstream we have concerns regarding the appropriateness of certain PacifiCorp assumptions in running the model (such as concerns about not consistently applying connectivity factors, and inappropriate sediment yield assumptions for tributaries). To address these concerns, we used PacifiCorp's sediment budget, unaltered from PacifiCorp's AIR submission, except we changed some of the sediment input parameters based on our assessment of site conditions and review of available evidence. Modifications are as follows:

- For the Iron Gate reservoir tributaries, as well as Bogus and Willow creeks downstream of the dam, we averaged our suggested range of 150 to 190 tons/mile^2/year (including the 20 percent washload factor), resulting in a yield of 170 tons/mile^2/year.

[47]PacifiCorp described the methods used to estimate inputs to the sediment budget in its response (dated December 16, 2005) to our AIR WQ-5.

[48]To create a bedload transport rating curve, sampling must be conducted over a range of flows that exceed the threshold of bed mobility, yielding multiple data points upon which a curve can be fit.

Table 3-8. Sediment budget modeling results. (Source: PacifiCorp, 2005h; staff)

Project Reach	Geomorphic Reach (or Tributary Sediment Source)	Theoretical Average Annual Transport Capacity (tons/yr)		Average Annual Bedload Delivery (tons/ year)		Cumulative Average Annual Bedload Delivery (tons/ year)		Potential Average Annual Deficit or Surplus by Reach or Subreach (tons/yr)		Actual Average Annual Deficit or Surplus by Reach or Subreach (tons/yr)		Cumulative Deficit (or Surplus) to Downstream Reach (tons/year)	
		FERC Analysis	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**
Link	Link River/Keno reservoir	249,487	249,487	169	169			-249,318	-249,318	-169	-169		
Subreach Total		**249,487**	**249,487**	**169**	**169**			**-249,318**	**-249,318**	**-169**	**-169**	**0**	0
Keno	Keno reach	899,654	899,654	3,032	3,032	3,032	3,032	-896,622	-896,622	-3,032	-3,032		
	JC Boyle reservoir	0	0	3,102	3,102	6,134	6,134	-893,520	-893,520	-3,102	-3,102		
Subreach Total		**899,654**	**899,654**	**6,134**	**6,134**			**-893,520**	**-893,520**	**-6,134**	**-6,134**	**-6,134**	**-6,134**
J.C. Boyle													
	J.C. Boyle bypass	255,853	255,853	4,104	4,104	4,104	4,104	-251,748	-251,748	-4,104	-4,104		
	J.C. Boyle USGS Gage/Frain Ranch	142,080	142,080	1,798	1,798	5,903	5,903	-249,950	-249,950	-1,798	-1,798		
	J.C. Boyle Gorge	210,771	210,771	3,421	3,421	9,323	9,323	-246,529	-246,529	-3,421	-3,421		
	J.C. Boyle Shovel Creek	197,114	197,114	2,572	2,572	11,895	11,895	-243,957	-243,957	-2,572	-2,572		
	Copco Reservoir	0	0	3,522	3,522	15,417	15,417	-240,436	-240,436	-3,522	-3,522		
Reach Total		**805,818**	**805,818**	**15,417**	**15,417**			**-790,401**	**-790,401**	**-15,417**	**-15,417**	**-21,551**	**-21,551**
Copco													
	Copco Bypassed reach	475,785	475,785	15	15	15	15	-475,770	-475,770	-15	-15		
	Iron Gate reservoir	0	0	33,667	9,603	33,682	9,618	-442,103	-466,167	-33,667	-9,603		
Subreach Total		**475,785**	**475,785**	**33,682**	**9,618**			**-442,103**	**-466,167**	**-33,682**	**-9,618**	**-55,233**	**-31,169**
Iron Gate													
	Bogus Cr	2,450	2,703	3,668	8,272	3,668	8,272	1,218	5,570	1,218	5,570		
	Willow Creek	same	same	3,989	8,995	7,657	17,268	5,206	14,565	-3,989	-8,995		
Subreach Total		**2,450**	**2,703**	**7,657**	**17,268**			**5,206**	**14,565**	**5,206**	**14,565**	**-50,027**	**-16,604**
	Cottonwood Cr.	19,300	19,300	3,376	44,678	3,376	44,678	-15,924	25,379	-3,376	25,379	**-65,951**	**8,775**

Project Reach	Geomorphic Reach (or Tributary Sediment Source)	Theoretical Average Annual Transport Capacity (tons/yr)		Average Annual Bedload Delivery (tons/ year)		Cumulative Average Annual Bedload Delivery (tons/ year)		Potential Average Annual Deficit or Surplus by Reach or Subreach (tons/yr)		Actual Average Annual Deficit or Surplus by Reach or Subreach (tons/yr)		Cumulative Deficit (or Surplus) to Downstream Reach (tons/year)	
		FERC Analysis	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**	**FERC Analysis**	**PacifiCorp Analysis**
	Shasta R.	same	same	9,514	356,783	12,890	401,461	-6,410	382,161	-6,410	-356,783	**-72,361**	**390,936**
	Lime Gulch	same	same	5,023	16,621	17,913	418,082	-1,387	398,783	-1,387	-16,621	**-73,747**	**789,719**
	Mainstream Tribs.	same	same	44,996	115,046	62,909	533,128	43,609	513,828	43,609	-115,046	**-30,138**	**1,303,547**
	Vesa Cr.	same	same	3,824	7,967	66,733	541,095	47,433	521,795	-3,824	-7,967	**17,295**	**1,825,342**
	Beaver Cr.	same	same	27,864	48,980	94,597	590,075	75,297	570,775	-27,864	-48,980	**92,592**	**2,396,117**
	Horse Cr.	same	same	18,015	27,388	112,612	617,463	93,312	598,163	-18,015	-27,388	**185,905**	**2,994,280**
Subreach Total		**19,300**	**19,300**	**112,612**	**617,463**			**93,312**	**598,163**	**93,312**	**598,163**	**43,286**	**581,559**
	Scott River	589	589	486,121	366,055	486,121	366,055	485,533	365,467	485,533	365,467		
	Upper Grinder Cr.	same	same	15,541	19,426	501,662	385,481	501,074	384,893	-15,541	-19,426		
	Seiad Cr.	same	same	10,401	13,002	512,064	398,483	511,475	397,894	-10,401	-13,002		
Subreach Total		**589**	**589**	**512,064**	**398,483**			**511,475**	**397,894**	**511,475**	**397,894**	**554,761**	**979,454**

- For Bogus and Willow creeks downstream of Iron Gate dam, we reduced PacifiCorp's sediment yield by 20 percent to account for suspended load, as PacifiCorp did on upstream tributaries. We also gave these two tributaries connectivity factors (moderate for both creeks) as PacifiCorp did on upstream tributaries. We base this change on our site visit observations, and conclude that there is no basis to disregard suspended sediment, particularly given the relatively intensive land uses in watersheds such as those of the Shasta River and Cottonwood Creek.

  We reduced the yield of Cottonwood Creek from 450 tons/mi^2/yr to 170 tons/mi^2/yr. Although we agree with PacifiCorp that geology does change downstream of Iron Gate dam, based on our site observations and review of available information, we conclude that to use the same sediment yield as the far-downstream Salmon River for this drainage is inappropriate, particularly given the diminished supply of gravel in this stream from extraction for construction of Interstate 5. Also, consistent with PacifiCorp's methods used upstream, we included a low connectivity factor to account for the broad Hornbrook Valley. Our configuration of sediment yield for Cottonwood Creek acknowledges a geologic difference from upstream terrain, but allows for a more-gradual transition to the higher sediment yields we know to exist further downstream.

- We reduced the yield of the Shasta River from 450 tons/mi^2/yr to 15 tons/mi^2/yr, based on information from Buer (1981). Although the confluence of this tributary is further downstream than Cottonwood Creek, the dominantly spring-fed Shasta River flows through a broad valley comprised of volcanic geology, before dropping steeply to meet the Klamath River. We conclude that this large valley (and Lake Shastina) has a substantial ability to store upland sediment, and as such, the watershed yields far less bedload sediment than Cottonwood Creek. Further, Buer (1981) estimated bedload transport from the Shasta River to the Klamath River at 5,000 yd^3/yr (~10 tons/mi^2/yr using a conversion factor of 1.485 tons/yd^3), so our estimate is probably an over-estimate, but still reasonable. Because this is based on Buer's actual estimates of bedload yield to the Klamath, we did not use a connectivity factor.

- For tributaries between the Shasta and Scott rivers—all of which drain similar terrain—we assumed a sediment yield of 170 tons/mi^2/yr, and then increased the yield by 50 tons/mi^2/yr for each tributary downstream. This progressive approach acknowledges that yields likely begin to increase in this part of the Klamath River Basin; however, it also acknowledges that the terrain and geology in this area are more stable than further west (where the 450 tons/mi^2/yr-Salmon River estimate was generated), and also accounts for the progressive increase in precipitation that occurs to the west.

- Based on information developed by NCRWQCB (2005), we have increased the sediment yield of the Scott River to 747 tons/mi^2/yr. We conclude that given the recent and highly focused nature of the work that went in to the generation of this yield estimate, it is perhaps the most-accurate of any of the sediment yields being used in the sediment budget.

Table 3-8 shows the results of our analysis. The theoretical sediment transport dynamics downstream of Iron Gate dam show two changes. These changes influence the transition from a supply-limited system to a potentially transport-limited system, and ultimately to the recovery of the sediment deficit from upstream project dams. First, the channel gradient decreases, generally by an order of magnitude compared to upstream reaches, which decreases the sediment transport capacity of the lower reaches. Second, the geologic terrain of tributary watersheds begins the transition from relatively low-yield Cascade volcanics to the higher-yield Klamath geology. Because of these changes, our results (using PacifiCorp's sediment budget with our input data) indicate that somewhere near Lime Gulch (RM 169.7) the river recovers from its cumulative bedload deficit. As discussed below, we have doubts that

these results are definitive in estimating the location of recovery from the sediment deficit, and provide additional analysis to supplement our sediment budget results.

Downstream Extent of Sediment Deficit: Defining a Portion of the APE. We assessed the downstream extent of project effects (to assist in determining the APE for cultural resources) on sediment deficiency by reviewing PacifiCorp's "quantification of alluvial features with distance downstream of Iron Gate dam" in light of our sediment budget analysis and other available information. In the broadest sense, the sediment deficit caused by project dams can be viewed to continue all the way to the mouth of the Klamath River. Indeed, Willis and Griggs (2003) conclude that Klamath River sand and gravel supply to the Pacific Ocean is reduced by 37 percent because of project dams and other dams on the Klamath (Link River) and Trinity rivers. However, this appears to be based on an approach that does not account for the strong variation in sediment contribution by watershed area that exists between the project area (and the watershed upstream of Upper and Lower Klamath lakes) and the area of the watershed including, and downstream of, the Scott River. Further, because the Klamath River becomes transport-limited[49] in its lower reaches, the sediment deficit is only really important upstream in the local reaches where the river would have stored that sediment in the channel, in bars, or on the floodplain, creating and maintaining aquatic and riparian habitat. Once the river has a surplus of sediment, the deficit from upstream simply reduces that surplus. Given the very considerable sediment yields from tributaries such as the Scott, Salmon, and Trinity rivers, we conclude that project-related sediment deficits do not adversely affect conditions to the mouth of the Klamath River or down the coast.

The sediment budget results indicate that sediment supply exceeds transport capacity locally at several cross sections downstream of Iron Gate, and exceeds the river's cumulative deficit somewhere between RM 169.7 (Lime Gulch) and RM 164.3 (Vesa Creek), which would indicate substantial average annual storage at and downstream of this location. However, available data to create and drive the sediment budget are limited, and there is evidence[50] that the sediment budget—regardless of the configuration of sediment inputs—is probably not an entirely accurate or definitive means to ultimately determine the downstream extent of project effects on sediment. Therefore, we also reviewed other information such as PacifiCorp's alluvial features analysis and, to the extent possible, conditions using aerial photographs submitted by PacifiCorp (December 14, 2005) in response to our AIRs.

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[49]Further, inputs of sediment from land management activities have increased sediment yields in the lower Klamath River Basin above natural levels. We are not able to determine if those increases exceed the sediment deficit caused by the project. However, as previously noted, the project-related deficit only applies where that sediment would normally be in use in the channel or floodplain. Any sediment in surplus of capacity (which is great in the lower Klamath River) would be in storage upstream.

[50](1) PacifiCorp notes that "It is likely that the theoretical transport capacities for the study reaches downstream of Iron Gate dam were significantly underestimated…Thus, the actual sediment transport capacity is almost certainly greater than is implied by these uncalibrated model results. Moreover, there is no geomorphic evidence of channel aggradation in this reach, as implied by the model results." Our own site visit observations and review of photographs concur with this. (2) Cross sections used in PacifiCorp's sediment budget are not equally spaced or necessarily frequent enough to accurately characterize reaches of river that span many miles. In short, the resolution of the model is such that accurately pinpointing where the sediment deficit ends is difficult using currently available tools and data. (3) Hydraulic calculations in PacifiCorp's sediment budget predict sediment movement in the reaches of river immediately downstream of Iron Gate dam on average only every 4 to 9 years. If the bed were only mobilized that rarely (and tributaries input the amounts of sediment assumed by PacifiCorp), we would expect to see aggradation and signs of sediment deposition—neither of which is supported by the license application or our site visit observations.

In its license application, PacifiCorp quantified the area and number of alluvial features downstream of Iron Gate dam to RM 133. It also examined valley width at the location of alluvial features in relation to channel slope. We further investigated alluvial features in available historic aerial photographs to determine if there were any detectable changes in the composition of alluvial features through time and to see if there were any discernable changes after large flow events, such as in the years 1955 and 1997.

We agree with PacifiCorp that the area of alluvial features (rather than number of features) is probably a better indication of the effects of project facilities downstream of Iron Gate dam. The area of alluvial features mapped by PacifiCorp downstream of Iron Gate dam is less than 0.2 acre for the first 9 miles downstream of Iron Gate dam. This is likely due in part to sediment trapping by project dams (especially immediately downstream of Iron Gate dam) and the relatively narrow width of the valley upstream of Cottonwood Creek. The area of alluvial features increases and peaks around RM 171 (an area extensively mined) and then decreases to the second trough at RM 151 (0.2 acre/mile). Downstream of RM 152 the area of alluvial features increases, and once downstream of the Scott River confluence this likely corresponds to the substantial sediment yields from that river. We also agree with PacifiCorp's conclusion that sediment yield (and in our opinion, transport capacity as driven by channel configuration) is more likely to control the number and extent of alluvial features than is valley width.

Changes in the composition and yearly extent of alluvial features in the available historic aerial photographs are difficult to discern. Because of the limited availability of photographs and the lower resolution of the images, for bars and deposits that persist from year to year, it is difficult to determine if those features are growing or shrinking, or if they appear coarser than in earlier photos. Further, differing flow levels complicate this sort of analysis. It is more conclusive to track the planform and nature of channel migration (or lack thereof) through time. For instance, in general, it appears that in more-recent photos (i.e., the 2001 USGS Digital Ortho Quarter Quadrangles) the channel margin is currently lined with a fairly consistent band of mature riparian vegetation (Ayres [1999] notes the occurrence of low cobble-boulder benches along the channel). This mature riparian margin does not appear to be as consistent in older (1944) photographs, and floodplain areas show signs of scour and inundation absent in later photos. So, while many of the alluvial features do not appear to have emerged or disappeared through time, there are some indications that through time they may not be inundated as frequently (potentially because of channel incision or because coarse sediment or riparian berms are holding it in place). We concur with Ayres (1999) that many of the coarse cobble and boulder features currently in the channel and floodplain are likely remnants of in-channel mining (at least in locations where that activity occurred). However, the effects of sediment starvation from upstream project dams probably hampers, to some extent, the recovery of the channel from in-channel mining.

We were also able to see that the channel's interaction with mine tailings in the area of RMs 169 to 172 (from photos in year 1955 through 2001) has been such that the channel has simplified and become locked in place by coarser cobble and boulder tailings (see below), but in isolated areas (such as at RM 170.2, as noted by Ayres, 1999) mine tailings are finer grained and contribute a substantial amount of sediment in such areas. This mining area, along with contributions from local creeks, probably mark a turning point where more alluvial features are present along the river, and sediment supply may begin to overcome the deficit caused by upstream project dams. However, as previously mentioned, because of the uncertainty in the sediment transport calculations in PacifiCorp's sediment budget, and in our attempt to conservatively estimate the downstream extent of project effects on sediment, we conclude a sediment deficit could easily exist to the confluence with the Scott River (RM 143). The deficit almost certainly does not persist downstream of the Scott River because this watershed inputs more sediment than the entire Klamath River upstream of that confluence.

Our conclusion is based on available information. As the channel evolves, it is likely to continue its trend of becoming straighter (at least in locations where it is currently working its way through alluvial deposits left from mining or other activities), more simplified, and more capable of sluicing finer

sediments from and through the channel. Through time, the river may winnow all the in-channel mining material (and perhaps floodplain mining material, if it can be accessed by the river) for which it is competent to carry. This could eliminate this area as a supplemental source of finer material, and result in the location of the downstream extent of the sediment deficit gradually moving downstream.

Proposed Measures to Augment Sediment Supply. PacifiCorp's proposal to place up to 200 cubic yards of spawning gravel in the upper end of the J.C. Boyle bypassed reach and up to 3,500 cubic yards downstream of Iron Gate dam and upstream of the Shasta River confluence, and to monitor these efforts, would enhance spawning habitat that may have been adversely influenced by the sediment deficit and armoring of the channel in those two reaches created by project dams, and enable evaluations of whether gravel remains in place and available for salmonid spawning. However, compared to the actual sediment deficit in those reaches, and the competence and capacity of those reaches to transport sediment, there is no basis to conclude that such quantities would provide meaningful long-term enhancements to spawning habitat value if they were one-time placements. Further, this measure does not compensate for any of the fine-sediment deficit, which is important for riparian vegetation (as is discussed in section 3.3.1.2.5, *Fluvial Geomorphic Effects on Riparian Vegetation*, the role of finer sediment sizes [those particles not transported as bedload] is important for developing and maintaining conditions conducive for riparian vegetative communities).

The Bureau of Land Management's specification to develop a river sediment management plan for the J.C. Boyle bypassed and peaking reaches could provide for measures that would increase channel complexity and availability of spawning habitat for resident and any anadromous fish in those reaches. The minimum quantity of gravel to be added would be 1,226 tons/year (about 850 cubic yards/year) and the maximum amount is 6,134 tons/year (about 4,100 cubic yards). The adaptive aspects of the plan would be used to modify the plan for 10-year sediment management cycles, which would ensure that management (i.e., the size, amount, and frequency of augmentation) is appropriate to meet plan goals, including riparian resources. We are uncertain that the specified minimum and maximum volumes of sediment in the Bureau of Land Management's measure are appropriate bracketing points from which to begin augmentation. An adaptive approach to sediment augmentation, as recommended by Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe, that begins by mapping existing spawning gravel deposits and alluvial surfaces suitable for riparian recruitment and, based on the results of that mapping, develops sediment augmentation volumes, locations, and sizes that meet plan goals, would provide habitat enhancements based on the flow regime that may be included in a new license. Monitoring initial sediment augmentation efforts would enable subsequent augmentation efforts to reflect replenishment needs based on the intervening flow regime. We expect that, during some years, it may not be necessary to provide any augmentation if previous gravel has remained at locations that would provide appropriate spawning habitat (e.g., during relatively dry years). During wet years, larger quantities of gravel may be needed to augment gravel washed downstream from suitable spawning areas. The reporting aspects specified by the resource and land management agencies and the Hoopa Valley Tribe for sediment augmentation would provide for coordination and review of the program by the Commission and stakeholders, and allow for consultation regarding any proposed changes to implementation and monitoring. This approach would facilitate any future augmentation necessary to meet habitat objectives in these reaches.

Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe recommendations pertaining to sediment augmentation would all work together to address any lack of spawning substrate. The objectives would largely focus on providing suitable spawning habitat and do not appear to be intended to address the finer sediment components that influence riparian vegetation.

Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe specify that PacifiCorp should develop multiple plans that address sediment augmentation (e.g. a gravel resource management plan, a gravel and sediment plan, and a gravel monitoring plan). The need to develop multiple plans to address sediment management is not clear to us (i.e., a sediment and gravel resource management plan

that is distinct from a sediment and gravel plan). We consider it more practical and efficient to develop a single plan that addresses consultation, specific measures that would be implemented, reporting requirements, and how adaptive strategies would be implemented.

NMFS's and FWS's recommendations are similar to those of the other resource agencies and also would have PacifiCorp identify priority spawning and holding reaches in reaches within the project area and downstream of Iron Gate dam. Within an adaptive management context these measures would assess the flows needed to transport gravels and maintain holding habitat (pools). This would help identify and refine priority areas for sediment augmentation, appropriate volumes of gravel to be deposited, flows to distribute gravel after deposition, and an appropriate schedule for periodic replenishment of gravels. This measure would properly identify those locations where sediment augmentation would be most useful, and would examine the relationship between flows and habitat formation.

3.3.1.2.4 Effect of Project Operations on Erosion and Sediment Transport at Cultural Sites and Tributary Confluences

At the Shasta River confluence, the primary active channel of the Shasta River enters the Klamath River at the downstream end of its delta deposit. The Yurok Tribe suggests that the primary channels of the Shasta River and other tributaries (e.g., Omagar, Bear, and Pine creeks) have recently shifted downstream from the centers of those streams' deltas. The tribe also notes that Pine Creek is no longer directly connected to the mainstem Klamath because the bed of Pine Creek has aggraded and its base flow now infiltrates before reaching the Klamath River. They suggest this condition could be a substantial barrier to fish passage.

At the Ukonom Creek confluence, a large landslide just upstream of the confluence (in the Ukonom drainage) is the source of a large episodic delivery of sediment. Tribal representatives suggest that several long, deep pools downstream of this confluence have been filled by fine sediment and no longer provide cold-water habitat for migrating salmon. At the Rock Creek confluence with the Klamath River, flow through the delta formation at the confluence seems to have shifted recently to the downstream end of the delta.

At Ishi Pishi Falls, Karuk Tribe oral histories suggest that floods much larger than the 1964 flood have occurred on the Klamath River in recent centuries. Despite this perceived reduction in recent flood flows, tribal representatives note increases in the recent rate of erosion that they feel are correlated with the construction and operation of project facilities. They note specific locations in this area that, in their opinion, were adversely affected during the 1997 flood. Also, the erosion rate observed by tribal representatives at specific ceremony sites has apparently increased over the past 25 to 50 years.

Our Analysis

PacifiCorp's geomorphology study did not attempt to detect historical changes in the active channel paths through confluence delta deposits, as this would have entailed detailed aerial photograph analysis and field studies to determine if some systematic change has occurred and to assess whether such a change was linked to project effects. However, we conclude that project reservoirs have had little effect on high flows because they have relatively limited storage capacity. Reclamation restricts releases from Link River dam from about October through April to allow Upper Klamath Lake to refill after it is drawn down during the irrigation season, and thus exerts a strong influence on flows entering and leaving the project during this period. Large flood events still occur downstream of Iron Gate dam but are unrelated to project operations. Consequently, aggradation at tributary confluences is not likely caused by the project, but more likely attributable to variations in sediment delivery from tributaries to the mainstem. For instance, in the watersheds of the Shasta River and nearby creeks, sediment transport to the Klamath River during the 1997 flood event was perhaps the greatest in recorded history. As subsequent peak flows (smaller than that of 1997) have traveled down those stream channels, the relatively large sediment deltas

at the mouths of those streams have likely been eroded, with channels becoming inset upon the deltas. Shifts of those inset channels are largely a function of the flows and sediment loads in the tributary streams, which are not influenced by project operations.

In the areas of Ukonom Creek and Rock Creek, it is likely that the filling of any deep pools in the Klamath River with fine sediment is caused by sources of fine sediment in tributary watersheds, such as timber harvest and road construction. Lying more than 100 miles downstream of Iron Gate dam, channel processes related to pool filling at these sites are likely overwhelmed by tributary flows and sediment loads with distance downstream of Iron Gate dam. Similarly, at Ishi Pishi Falls, direct project effects are likely overwhelmed by tributary flows and sediment loads because of the considerable (over 100 miles) distance downstream of Iron Gate dam. The degradation of various cultural sites occurred during large floods (e.g., 1997), whose magnitude would be unaffected by project operations, and during which a wide range of other processes (natural and human-induced) occur (e.g., the massive landslide on the mountain downstream of Ishi Pishi Falls on the left side of the river).

3.3.1.2.5 Fluvial Geomorphic Effects on Riparian Vegetation

In terms of riparian vegetation recruitment and geomorphology, the two key elements for successful recruitment are clean, bare mineral soil and adequate hydrologic conditions. Both variables are altered on the Klamath River through the project area.

The California Indian Basketweavers Association and Interior (in comments on our SD1) state that flow releases from project dams interfere with the renewal pattern of riparian willow shoots downstream of Iron Gate dam. They indicate that the existing flow regime seems to promote colonization of willow shoots by insect larvae, which makes them unsuitable for use for weaving baskets. The Karuk Tribe has indicated that fresh willow growth on gravel bars (the growth that produces the best basket materials) has become less common in the region near Ishi Pishi Falls. They also state that following naturally occurring spring freshet flows, the exposed willow roots are gathered for basket weaving, and the altered hydrograph no longer is sufficient to expose willow roots.

Our Analysis

For the hydrologic element of recruitment, spring peak flows (those able to scour soil surfaces) and the descending limb of the annual hydrograph relative to seed dispersal are the most important aspects for riparian establishment. Because riparian seedlings are intolerant of drought, the timing and rate of drop of the descending limb with respect to the elevation of the seed is important. In general, river water levels that decline too rapidly are a primary cause for failure of cottonwood and willow to regenerate because root growth cannot keep pace with the drop in river stage. Mahoney and Rood (1998) developed the box model for riparian recruitment, detailing the requirements of the hydrograph relative to the timing of seed dispersal (figure 3-4). If river water levels decline too rapidly, tree seedlings will not be able to grow roots fast enough to follow the coincident decline in soil moisture (caused by the drop in the water table), and the seedling will die of desiccation. Young trees can also be killed by inundation (from later-season flow increases), or scour in subsequent years because they recruited too low. Rood and Mahoney (2000) cite various studies that consistently determined that a drop of about 2.5 centimeters per day or less is required for seedling survival.

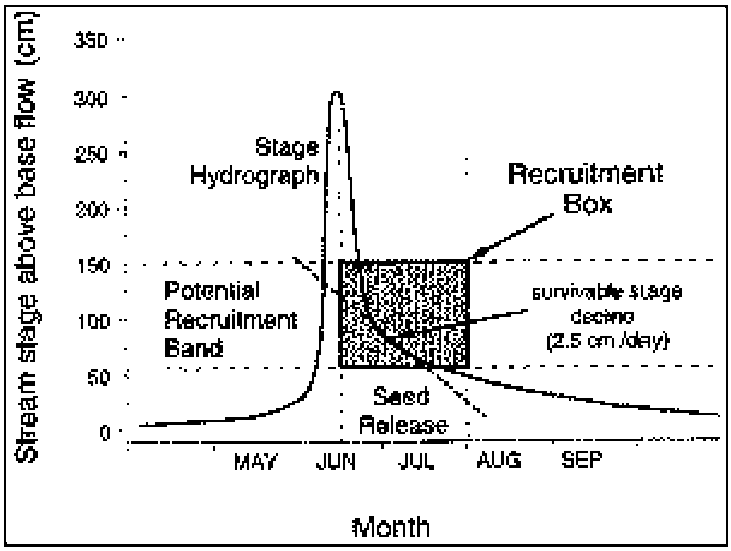


Figure 3-4. Conceptual diagram of the box model for riparian recruitment. (Source: Mahoney and Rood, 1998)

PacifiCorp provided analysis on the relationship of past flows and riparian vegetation recruitment and we review those results here. We also assess Reclamation's recently implemented (March 2006) 2002 BiOp phase III flows discharged from Iron Gate dam. PacifiCorp assumes that coyote willow seed disperses in May and June and collected data accordingly.[51] However, because only incidental observations of coyote willow seed dispersal were made in late May or early June 2002, these observations may not reflect the time period when the majority of willow seed (coyote or other species) dispersal occurs. If most seed dispersal occurs earlier or later than May or early June, willow recruitment could be different from that portrayed in PacifiCorp's results. Additionally, PacifiCorp did not excavate to the root crown of the trees that it cored and age-dated. The clonal habit of coyote willow growth makes it difficult to know if the tree-age samples are the result of vegetative expansion by suckers (after, for instance an event that flood trained and buried the original stem that grew from seed), or of sexual reproduction from seed. Excavating and finding the original root crown is the only way we know of to definitively determine the mode of reproduction, and this was not a part of the PacifiCorp's methods.

Relatively fine substrate is necessary for the recruitment of riparian vegetation (Mahoney and Rood, 1992). The bedload sediment deficit within the Klamath River was assessed in previous sections, with bedload assumed to be about 10 percent of the total sediment load. Therefore, the deficit of finer sediments is roughly nine times as great as the results presented for bedload. Although flows in many reaches may not be able to mobilize the D_{50} sediment size, flows have likely been more than sufficient to mobilize and winnow away the finer (sand, silt, and clay) particle sizes—the particle sizes that are important for colonization by many species of riparian vegetation.

J.C. Boyle Bypassed Reach. Conditions for riparian vegetation in the J.C. Boyle bypassed reach are naturally limited by the narrow width of the valley bottom and the amount of that bottom width occupied by the channel. Despite this fact, scattered areas of fine sediment deposition along the channel margin do support a relatively narrow fringe of riparian vegetation. Through the reach below the canal and emergency spillway, substantial portions of the right bank are comprised of coarse material from the road upslope. The material has constricted the channel and has altered the riparian vegetation along much of the reach. Common woody riparian vegetation does not become established in the coarse (cobble,

[51]Coyote willow is the most abundant willow species along the Klamath River from Iron Gate dam to the Shasta River.

boulder, and larger) material coming from upslope; frequently it is displaced by reed canarygrass, an ecologically undesirable species that provides little habitat for native fauna. Reed canary grass can adversely affect downstream channel formation by effectively trapping sand, gravel, and small cobble in its dense root mass. Such material would otherwise be transported downstream where it would replenish similar sized bed material scoured by floods. Approximately two-thirds of the riparian habitat in the J.C. Boyle bypassed reach is riparian grassland, which is predominately reed canary grass. Further, sediment supply to the reach is largely eliminated by J.C. Boyle dam, and few sources of sediment (aside from the coarse fill encroachment) occur upstream of the emergency spillway blowout.

J.C. Boyle Peaking Reach. Geomorphic characteristics vary considerably throughout the J.C. Boyle peaking reach. For example, we would not expect there to be extensive cottonwood recruitment through the steep, bedrock-controlled gorge reach. We observed a distinctly-bare "bathtub ring" in the zone of fluctuating inundation from peaking operations, even in the gorge. Riparian vegetation on bars in the alluvial portions of the reach appeared to be affected by the hydroperiod from peaking operations. Although the sediment composition of most alluvial bars appeared amenable to riparian vegetation recruitment and growth, the bars were unvegetated to the margin of inundation during peaking, indicating that project effects are limiting recruitment and growth within that zone of fluctuation.

Coyote willow does persist along the river outside the zone of fluctuation. Tree age data were collected by PacifiCorp at vegetation transects 2015B (RM 204.6) and 177B (RM 206.5). The ages determined for some of the older coyote willow trees were somewhat unreliable because of rot; the estimated ages of the older willows ranged from 42 to 66 years old. Observations of younger trees by PacifiCorp surveys were evidently limited, and our site visit observations agree. One site analyzed by PacifiCorp indicated that the younger willows it investigated would not have been able to recruit via seed because of inundation (over 700 times in the 2 years bracketing the age date of the willow). PacifiCorp suggests, and we concur, that this type of inundation pattern is not conducive to reproduction of coyote willow from seed. Although recruitment via seed has likely been diminished (or in some areas, eliminated) in this reach, coyote willow in the J.C. Boyle peaking reach can clearly increase its distribution by suckering when conditions are right and probably contributes to the ability of this species to persist on in-channel bars and islands between establishment events that are likely quite infrequent.

Copco Reach. Project-related effects on riparian vegetation and geomorphology in the Copco No. 2 bypassed reach are related to the absence of intermediate flows, diminished sediment supply, and occasional peak flows that scour the channel of finer sediment and young vegetation. This has created a reach where mature alders have rooted in and fossilized large cobbles and boulders in the active channel. Because these conditions have persisted for many years and high flows are obviously not sufficient to clear the channel, mechanical removal of vegetation may be the only way to re-establish the open canopy and bare-surface conditions necessary for seed-recruitment of riparian vegetation.

Downstream of Iron Gate. The river reaches immediately downstream of Iron Gate dam are constrained by geomorphology, with little meandering or aggradation evident. This changes downstream (near RM 171) where alluvial deposits increase, and some channel meandering within alluvium occurs. In our review of historic aerial photographs, the established riparian vegetation along the relatively narrow river banks and minor floodplains appear relatively unaffected by large flows, although the resolution of the images makes it difficult to discern what is happening with younger vegetation.

Downstream of Iron Gate dam, PacifiCorp conducted more extensive analysis on the geomorphologic factors influencing recruitment of riparian vegetation. It undertook analysis of some of the factors that influenced the recruitment of existing riparian vegetation, and focused in particular on stage, elevation, and timing relationships in an effort to document whether conditions for the successful recruitment of vegetation downstream of Iron Gate dam currently exist. A key component of that work

involved determining the age of trees,[52] thereby yielding the likely year of recruitment. Subsequently, PacifiCorp examined the flows and recession rates during the respective recruitment years for a small set of sampled trees.

PacifiCorp makes no definitive conclusions on the role of project operations and geomorphology on existing conditions for riparian recruitment. However, we have reservations in using PacifiCorp's analysis results to draw our own conclusions because of several limitations in its study methods.

First, because riparian trees in alluvial environments are frequently flood trained or damaged, tree trunks at the ground surface cannot be assumed to necessarily represent the original stem coming up from the taproot, nor the elevation at which recruitment occurred. PacifiCorp conducted riparian tree age dating on 29 trees using coring or cutting techniques with no indication that excavation to the root crowns was completed for these cuttings or cores. Such excavation is necessary to (1) determine that the tree trunk being sampled is the product of sexual reproduction (i.e., riparian recruitment) and is not a clonal re-sprout off a branch, log, or flood-trained trunk; and (2) ensure that the core or cutting is taken in the most appropriate location to determine the true age of the individual because the main trunk of the tree can break off and re-sprout at unknown locations. This is particularly important because coyote willow is a clonal species that can spread by creeping rootstocks that generate new shoots forming multi-stemmed, dense thickets (Forest Service, 2004). Hence, dendrochronologic work undertaken by PacifiCorp does not address the basic question of whether these trees established via sexual reproduction (i.e., seed recruitment) or if they are the result of stump sprouting. PacifiCorp notes in one instance that "it is also possible that the presence of this tree is the result of clonal growth by suckers."

Second, because the elevations of the trees were not measured at the root crown (the actual elevation at time of recruitment if the tree grew from seed), the elevations used by PacifiCorp to compute flows and recession rates are likely different from those that actually existed at the time of recruitment. In one instance, PacifiCorp notes that "Whether the island [the recruitment surface for a particular tree] was at the same elevation in 1967 as it is now is difficult to assess."

There is a probable connection between the recruitment and maintenance of young riparian vegetation and project effects on sediment supply and the river's altered hydrograph. Based on information available, we conclude that project effects on sediment supply may be combining with the Klamath River's altered flow regime downstream of Iron Gate dam (dictated primarily by the NMFS 2002 BiOp for Reclamation's Klamath Irrigation Project) and other factors to have a cumulative effect on riparian vegetation.

PacifiCorp concludes that "minimal willow reproduction [was] observed" in the reach below Iron Gate dam, and goes on to suggest that "it may be that there are no river bars at appropriate elevations to support cottonwood and species of willow other than coyote willow." We agree with this conclusion, but also conclude that, although bars may be too high for effective riparian recruitment, this could be a result of channel entrenchment caused by flow and sediment alterations from upstream project dams. Alternatively, these bars may be at an appropriate elevation but too coarse because of scour and a lack of replenishing sediment. This latter notion is supported by PacifiCorp when it concludes that "it may be that the general scarcity of finer sediment moving through the river is limiting the ability of large flows to deposit fresh sediment into the floodplain…"

Reclamation's recently implemented (March 2006) 2002 NMFS BiOp Phase III flow regimes for discharges from Iron Gate dam (figure 3-5) suggest that the flow regimes for wet, above average, and average water year types would result in large decreases in stage during the recruitment period of May through June, with stage reductions in below average and dry water year types being less than during

[52]PacifiCorp's sample size was 29 trees for the reach from Iron Gate dam to Shasta River, a relatively low sample size of 2.4 samples per river mile.

wetter years. Determining precisely how these decreases in flow translate to stage-discharge relationships at unique recruitment sites downstream of Iron Gate dam would require additional analysis using data currently unavailable. However, our observation of recent downramping rates under Phase III during a 10-day period in mid-July (flow decreased from about 3,200 cfs to about 1,000 cfs in 10 days) indicates that stage can drop a little over 0.25 foot per day, as measured at the USGS gage downstream of Iron Gate dam. This rate of decline is too fast for tree roots to follow. For flows less than 1,750 cfs, the Phase III rate of decline would be about half as fast (about 0.125 foot/day), yet this lower ramp rate is also too steep to allow tree roots to chase the declining water table. As such, we expect that the Phase III flows would not provide the conditions needed for riparian recruitment at locations downstream of Iron Gate dam that are within the dam's range of hydrologic influence and have channel configurations similar to that of the USGS gage downstream of the dam.

Determining how our observations at the USGS gage downstream of Iron Gate dam translate to sites for the rest of the downstream reach would entail additional site reconnaissance and survey. However, because the river generally broadens with distance downstream, any decrease in discharge in a wider, broader channel would result in a smaller decrease in stage at that location. Therefore, although Phase III ramp rates might be too steep in the areas immediately downstream of Iron Gate dam, this effect may decrease with distance downstream, as channel morphology changes and as tributary discharges begin to mask the release pattern from Iron Gate dam.

No proposals or recommendations directly address geomorphologic effects on riparian resources. We discuss proposals and recommendations related to riparian vegetation in section 3.3.4.2, *Terrestrial Resources*. However, some proposed measures to address flows and sediment (discussed and analyzed in previous sections) also relate to how geomorphology relates to riparian vegetation.

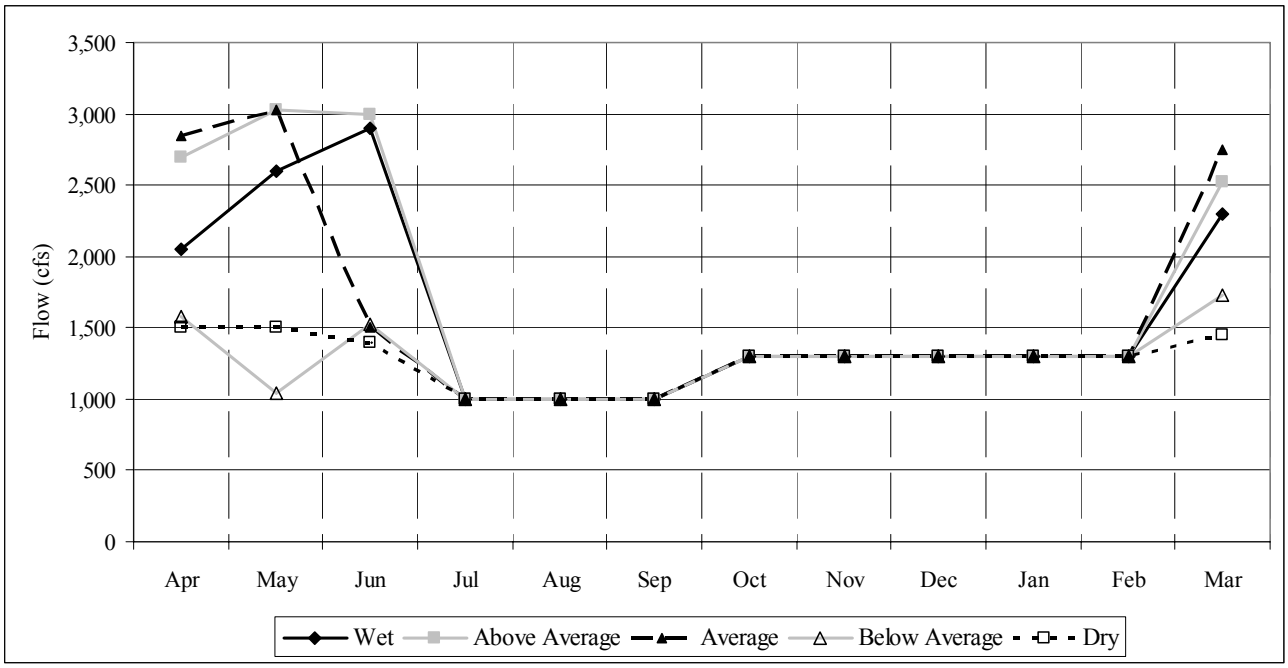


Figure 3-5. NMFS BiOp Phase III flow regimes for Iron Gate dam based on water year. (Source: Reclamation, 2006c)

Flow measures that increase base flows in project-affected reaches would increase the low-level stage within the channels, increasing the elevation above which successful riparian recruitment would be able to occur. Proposed measures that would augment sediment supply in project-affected reaches would likely be somewhat beneficial for riparian vegetation. Because almost all measures focus on spawning

gravel-sized sediment, benefits would be somewhat limited. Fine sediment is the more-important component for establishing riparian vegetation in areas where currently precluded by project operations.

3.3.1.2.6 Development Decommissioning and Dam Removal

Many parties recommend removal of some or all project dams to achieve water quality and anadromous fish passage objectives. Among the entities recommending removal of all project dams are the Institute for Fisheries Resources/Pacific Coast Federation of Fishermen's Associations and the Resighini Rancheria. Entities that recommend removal of the four lower mainstem dams include: Quartz Valley Indian Reservation; Klamath Tribes, Karuk Tribe, Yurok Tribe, Conservation Groups, NMFS, and the Pacific Fishery Management Council (PFMC). Additional entities recommend that if water quality or fish passage objectives cannot be achieved after feasible measures have been implemented, the specific development that does not achieve those objectives should be decommissioned and removed. Entities taking this approach include Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe. Nearly all entities that recommend dam removal also recommend the development of a decommissioning plan prior to dam removal that would address measures to minimize environmental effects.

Our Analysis

Potential effects of project dam removal related to geology and soils pertain to handling and disposition of sediment in project reservoirs prior to, during, and after dam removal. Effects of removal of the Fall Creek diversion dams on sediment would likely be minimal, other than to restore sediment transport to downstream reaches that are currently influenced by the diversion dams. However, we focus our analysis of dam removal effects on the mainstem dams. We first discuss the quantity of sediments that may be in each mainstem project reservoir followed by potential effects if the sediment is found to be contaminated, thus requiring special treatment as a hazardous waste, or if it is uncontaminated, and can reasonably be expected to be allowed to pass downstream via natural processes.

Reservoir Sedimentation. Removal of any mainstem dam would require addressing the disposition of sediment that has accumulated in each project reservoir. There is a considerable disparity in the estimates for project reservoir volume loss (see table 3-3), ranging from 0.6 percent in J.C. Boyle reservoir to 17.4 percent in Copco reservoir. The greatest loss in volume—that calculated for Copco reservoir—appears to be realistic considering that this is the oldest impoundment in the system (constructed in 1918), is deep and has a high trapping efficiency, and is situated in a portion of the project area with greater topographic relief than upstream reservoirs. Iron Gate reservoir would be expected to have a considerably lower degree of infilling because it is relatively young (constructed in 1962) and is located immediately below Copco reservoir, which would trap most sediment input.

For three of the impoundments, J.C. Boyle, Copco, and Iron Gate, the historical topography does not include elevation data below the original river channel. This results in underestimating the total loss of volume from sedimentation. We know the volumes computed for Keno reservoir are based on the bathymetry of the impoundment before dredging in the forebay began in 2002. However, it appears that the undated, historic contour map used by PacifiCorp to compare with the current bathymetric map was compiled before the substantial (up to 3.75 million cubic yards) amount of dredging between 1966 and 1971. Hence, the estimates of sedimentation in Keno reservoir may be understated.

Our review of available information leads us to conclude that PacifiCorp's estimate of the change in volume attributed to sedimentation at J.C. Boyle reservoir is unreasonably low. The reason for the low infilling calculated by PacifiCorp for J.C. Boyle reservoir may be related to the nature of the historical topography, which does not show a deep channel in the northern portion of the reservoir. However, for J.C. Boyle reservoir, the volume of the original river channel is much greater, relative to the volume of the impoundment. The degree to which the loss of reservoir volume is likely underestimated at J.C. Boyle is difficult to assess, but is likely greater than for other project reservoirs.

Sediment Disposal Prior to or During Dam Removal. The California State Coastal Conservancy sponsored a study prepared by Gathard Engineering Consulting (GEC, 2006), which reviewed the results of reservoir sediment sampling via a combination of over-water boring techniques and grab samples at 26 locations: borings were taken at 22 locations (1 in J.C. Boyle, 12 in Copco, and 9 in Iron Gate reservoirs) and grab samples at 4 locations (all in J.C. Boyle reservoir). Sediment samples were submitted for laboratory chemical testing and grain size analysis. Puget Sound Dredged Disposal Analysis protocol was selected as the protocol for evaluating possible contaminants in the reservoir sediments. This protocol has been used for approximately 20 years as a method of assessing suitability for sediment deposition in the marine water of Washington State's Puget Sound. GEC (2006) also considered use of a similar sediment testing protocol adopted for use in "Dredge material evaluation framework for the Lower Columbia River Management Area" issued in 1998, but elected to use the Puget Sound Dredged Disposal Analysis protocol because the guidelines had been used to perform sediment analysis on similar decommissioning projects, including the Elwha River Restoration Project, the Matilija Dam Removal Project, and the Condit Dam Removal Project. GEC (2006) indicates that EPA Region 9 uses the Puget Sound protocol as a guideline for dredging activities in that region since specific regional guidelines have not been established. GEC (2006) included additional test methods not included in the Puget Sound protocol, based on potential contaminants that could be present in project reservoirs and comments on the original sampling plan. We note that the Puget Sound protocol is intended to determine the potential risks associated with deposition of dredged material in a marine environment and the screening level criteria used may not be totally applicable to a freshwater environment. However, given that the results of GEC's study indicate that about 84 percent of the resuspended sediment following removal of Copco No. 1 and Iron Gate dams would remain in suspension until it reaches the ocean, we consider GEC's use of the Puget Sound protocol to be reasonable. Chemical analysis results showed one location in Copco reservoir where ethylbenzene and total xylenes in the sediment were present at concentrations exceeding the Puget Sound Dredged Disposal Analysis protocols. GEC's subconsultant reviewed the test results and concluded that these two volatile organic compounds measured in that one sample would be expected to volatilize during erosion and their concentration reduced as mixing occurs. They conclude that sediment chemistry would permit downstream erosion of river reservoir sediments (Shannon & Wilson, 2006).

Although sediment chemistry may permit erosion of reservoir sediments, GEC (2006) states that its conclusions "…provide an overview, but not a comprehensive analysis of dam removal and its effects on water quality. Much additional analysis will be required to fully evaluate dam removal as a preferred project management alternative." Shannon & Wilson (2006) state: "The sampling effort was limited in extent and serves as a first level screening effort only. It was not intended to absolutely define the lateral extent of sediment contamination, if any. Other areas of contamination that were not obvious during our site work could be present in the site." Thus, the GEC study and its supporting reports, although indicative that sediment from the reservoirs could be allowed to erode following dam removal without major resuspension of contaminants, should be considered preliminary and not a definitive affirmation of non-contaminated sediments.

If sediments in any reservoir are found to be contaminated and not suitable for downstream transport, it would likely be necessary to remove sediments that would be susceptible to scour following dam removal. The amount of sediment that would need to be removed would depend on site-specific conditions and the nature of contaminants; it could be feasible to allow sediments not subject to scour following dam removal to remain in place with or without capping or other protective measures. Mechanized removal would entail the removal of sediment from the reservoirs by hydraulic or mechanical dredging, or conventional excavation, for long-term storage at an appropriate disposal site. The disadvantages of mechanical removal are potential adverse effects from spoil piles, and construction effects on roads, air quality, and the reservoir site itself. It also can be difficult to remove all reservoir sediment. Stabilization in place is a method where project facilities are modified (typically this is a partially breached dam) and designed with appropriate protective measures against erosion, allowing

storage of at least some sediments in the reservoir over the long-term. This approach minimizes disposal site considerations.

If contaminated sediments need to be removed from project reservoirs, disposal sites would need to be identified. Appropriate sites might exist nearby; however, they would need to accommodate hazardous wastes, and the design of the site would need to incorporate specific provisions to accommodate the specific contaminants that might be present. Disposal site preparation would likely require clearing and grading, a source for capping material, and erosion control. It also would be likely that a long-term monitoring program would be needed to ensure that surface or groundwater is not contaminated by leachate from the disposal site. Regardless of whether reservoir sediments are contaminated, disposal sites for demolition material would be necessary.

Downstream Transport of Sediment During and Following Dam Removal. Not all sediment deposited in project reservoirs would be transported downstream following dam removal. Investigators estimate that about half of the sediment behind dams on the Elwha River would remain in place following dam removal and other investigators predict that from 65 to 85 percent of the coarse material and half of the fine sediments behind four dams on the Snake River would remain following dam removal (Heinz Center, 2002). Following the breach of the Gillespie Dam on the Gila River in Arizona in a 1993 flood, about half of the sediments in the reservoir remained in place (Heinz Center, 2002). Sediment that remains at the reservoir site would likely quickly revegetate after which high flow or precipitation events would result in minimal additional erosion of exposed sediments following dam removal. A study of 30 former reservoir sites in Wisconsin at varying years following dam removal found almost complete plant cover on all sites, including a site in its first growing season following dam removal (Orr and Stanley, 2006). In fact, Orr and Stanley (2006) report that it can take as little as 1 month for initial re-vegetation to occur and sites retain high vegetative cover. The authors suggest that rapid vegetation establishment may be typical for nutrient-rich bare soils, as would be expected following removal of any of the Klamath mainstem dams. Orr and Stanley (2006) state that if a restoration goal of dam removal is simple plant establishment, without concern for the species that colonize exposed sediments, then no active management intervention is needed.

If sediment in project reservoirs is allowed to be flushed downstream during and following dam removal; it would affect downstream habitat in the downstream portions of the Klamath River. If downstream dams remain in place, some sediment would be deposited in the next downstream reservoir. If more than one of the mainstem dams is removed, the most likely sequence would be to remove upstream dams first. This would allow releases when the downstream dam is removed to occur in a controlled manner. Based on work from Stillwater Sciences (2004), we assessed some of the effects of a natural release of reservoir sediment under several sets of hydrologic conditions. Stillwater used DREAM-1, a one-dimensional sediment transport model designed to assess sediment transport and deposition following dam removal for reservoir deposits primarily composed of sand. The model assumes that, following dam removal, the Klamath River would carve a channel with a trapezoidal cross section. The maximum amount of sediment that can be eroded and transported downstream is a function of the thickness of sediment deposit in the main channel (i.e., average thickness over the pre-dam channel bed). The channel is also assumed to occupy the historical Klamath River channel, and would not be expected to meander through the reservoir deposit and erode substantially more sediment than the volume necessary to create a single channel. Potential sediment release from erosion of lateral sediments outside the single channel was accounted for in the modeling using safety factors. Other detailed assumptions are described in Stillwater Sciences (2004). Stillwater Sciences reviewed the sediment particle size data reported in GEC (2006) and concludes that its 2004 modeling results still represent a valid worst-case-scenario in terms of downstream sediment deposition. We did not conduct an independent assessment of downstream sediment transport, but the Stillwater modeling provides a reasonable tool to conservatively assess what may occur if Copco No. 1 and Iron Gate dams are removed.

Table 3-9 shows the predicted thickness of the sediment deposit in Iron Gate reservoir. This thickness would be greater if upstream dams (Copco No. 1, Copco No. 2, and J.C. Boyle) were also removed before removal of Iron Gate dam; however, because of the relatively small volume of sediment in J.C. Boyle and Copco No. 2 reservoirs, only the sediment deposited in Copco reservoir was considered in Stillwater's modeling, because it would contribute to the sediment volume in Iron Gate reservoir.

Table 3-9. Estimate of sediment thickness in Iron Gate reservoir, as modeled by DREAM-1. (Source: Stillwater Sciences, 2004).

	Copco	**Iron Gate only**	**Copco release plus Iron Gate sediment in Iron Gate reservoir**
Total volume (yd^3)	10,370,000	4,810,000	9,943,000 (=5,135,000 + 4,810,000)
Depositional area (ft^2)	32,000,000	75,000,000	75,000,000
Thickness (ft)	8.75	1.73	3.58 (=1.85 + 1.73)
Safety factor	5	5	5
Estimated width (ft)	150	150	150
Estimated length (mile)	4	6.5	6.5
Estimated sediment release (yd^3) if deposits are uniformly distributed	1,000,000	330,000	680,000
Estimated sediment release (yd^3) with safety factor to be used in the model	5,100,000	1,600,000	3,400,000

Following the removal of Copco dam, the model predicts that flows would carve a channel similar in size to the pre-dam channel, which has an average width of approximately 150 feet. The volume released downstream to Iron Gate reservoir is modeled as the width of the channel multiplied by the average sediment depth and the length of the reservoir (4 miles), amounting to about 1,027,000 cubic yards of sediment released. As a safety precaution, Stillwater assumed that 5 times this amount would be released, i.e., the average thickness of sediment deposit to be released is 43.75 feet, and the volume of sediment to be released to Iron Gate dam following the removal of Copco No. 1 dam is 5,135,000 cubic yards, which is about half of the sediment deposit in the Copco reservoir. This five times thickness increase is very conservative for use across the entire reservoir, but might represent extreme conditions in isolated locations. Adding the 5,135,000 cubic yards of potentially mobile Copco sediment to Iron Gate reservoir results in an additional average depositional thickness of 1.85 feet in Iron Gate reservoir. Again, a safety factor was used to make it highly unlikely that calculation of the sediment release from Iron Gate dam is underestimated.

The model was run with different combinations of wet, dry, and average water year hydrographs, and also examined the role of the low-level outlet at Iron Gate dam. The following assumptions were used to model removal of Iron Gate dam: (1) the low-level outlet would be used to allow for reservoir draw-down during the base-flow season; (2) removal of the dam would occur above the water surface; and (3) removal of the underwater portion of the dam would occur as quickly as possible to complete dam removal. These are similar to the assumptions that we made in our independent assessment of the process of dam removal, described in section 4.7, *Conceptual Costs of Project Dam Removal*.

In the worst-case-scenario (a dry water year following 3 months of low flow at the beginning of reservoir drawdown), the model assumed that the removal of the dam would take 6 months to complete (i.e., the flow and sediment would pass through the outlet for the first 6 months of simulation and then

through the main channel once the dam was removed). Results of the simulation indicate that there would be a maximum of less than 4 feet of sediment deposition downstream of the dam and upstream of RM 183. After 2 weeks, the maximum sediment deposition would decrease to less than 2 feet. Almost all the sediment deposit is modeled to disappear in 6 months following the final stage of the dam removal, and no sediment deposition is predicted downstream of RM 183. Again, the prediction of this simulation represents a worst-case, dry-year scenario, with multiple safety factors; under actual conditions we expect that the sediment deposition downstream of Iron Gate dam would be substantially smaller following the removal of the dams.

The release of sediment from the reservoirs is not predicted to adversely affect flooding. Stillwater Sciences (2004) note that, if a high flow does occur, it might result in an increased stage height in the river, but the high flow would act to rapidly transport sediment, possibly during the rising stage of the flood, thereby minimizing the time period of elevated stage. There are several potential benefits of sediment discharged from the reservoirs, including a re-invigorated sediment supply that would benefit riparian vegetation, spawning gravel, and channel complexity. We conclude that the river is sediment starved downstream to about RM 170. The adverse effects of mining on the channel and floodplain in the reaches downstream of Iron Gate dam (such as constraint of the channel by bank and floodplain sediment too-coarse to be eroded and migrated through) would likely benefit from an influx of sediment, creating deposition of finer material on floodplains, diversifying monotonous plane-bed reaches, and potentially increasing sinuosity. Potential adverse effects include increased fine sediment in spawning gravels, pool filling, and increased levels of suspended sediment and turbidity. Most of these effects are predicted by Stillwater's DREAM-1 model efforts to be of relatively short duration. Based on the available information and modeling, we conclude that, although any dam removal option would need to be undertaken with substantial additional planning and studies, the downstream effects of sediment on resources is likely to be minimal, and relatively short term—particularly if dam removal occurs during a wet year.

3.3.1.3 Cumulative Effects

Our evaluation of cumulatively affected geomorphology resources includes sediment transport, substrate composition, and channel shape. Based on information available, we conclude that project effects on sediment supply may be combining with the Klamath River's altered flow regime downstream of Iron Gate dam (dictated primarily by the NMFS 2002 BiOp for Reclamation's Klamath River Project) and other factors to cumulatively affect riparian vegetation. Combined with any effects from Reclamation dams upstream, project effects on sediment supply may be decreasing the amount of sediment available for riparian recruitment in project reaches. In the Keno reach, the project-induced sediment deficit is combining with flow alterations from Reclamation's Klamath River Project (described in the terrestrial resources chapters of the license application) to adversely affect the conditions needed to recruit and maintain riparian vegetation.

Project dams contribute to a deficit of sediment supply from the upper watershed to the lower portions of the Klamath River Basin. However, as described previously, because sediment supply outpaces the ability of the river to transport it, this effect is local to the area upstream of about the Scott River. Therefore, it seems unreasonable to consider removing trapped sediment behind the dams to reduce any perceived effects on coastal shoreline erosion.

If any dams were removed, the cumulative effects on other resources from sediment dispersal (see section 4.7, *Conceptual Costs of Project Dam Removal*) might include increased fine sediments in spawning gravels; alteration of pools, riffles, and other important channel attributes of salmonid habitat; alterations to the flood capacity of the river in certain reaches; and increased difficulty of diversion for any domestic, municipal, or agricultural water diversions.

Environmental measures have been recommended by many entities that would reduce fine sediment input to the Klamath River (such as stabilization of eroding banks along the J.C. Boyle bypassed reach) and enhance spawning habitat downstream of Iron Gate dam through sediment augmentation. When considered over the life of a new license and in conjunction with similar enhancement efforts of TMDLs for the Scott River (fine sediment reduction) and the Trinity ROD (spawning habitat enhancement), implementation of such measures at the Klamath Hydroelectric Project would have cumulative beneficial effects on downstream water quality and salmon habitat.

3.3.1.4 Unavoidable Adverse Effects

Even with implementation of best management practices, project-related construction associated with recreation sites, major civil improvements (such as the flow continuation device at the J.C. Boyle powerhouse or decommissioning East Side and West Side developments), and major restoration activities that would be associated with the eroded slope at the J.C. Boyle emergency spillway may cause erosion and sedimentation. With appropriate erosion control measures in place, such effects, however, would be relatively minor and short-term.

3.3.2 Water Resources

3.3.2.1 Affected Environment

3.3.2.1.1 Water Quantity

The upper Klamath River Basin, above Iron Gate dam, is generally bordered by the Sacramento River Basin to the south, closed basins within the Great Basin to the east and north, and the Rogue River Basin to the northwest. Precipitation occurs mostly during the late fall, winter, and spring and is mostly in the form of snow above elevations of 5,000 feet. Average yearly precipitation varies greatly with elevation and location and ranges from about 10 to more than 50 inches. Streamflow normally peaks during the late spring and/or early summer from snowmelt runoff. Low flows within this watershed typically occur during the late summer or early fall, after the snowmelt and before the runoff from the fall storms moving in from the Pacific Ocean.

Upper Klamath Lake receives most of its water from the Williamson and Wood rivers (NAS, 2004). The Williamson River watershed consists of two subbasins drained by the Williamson and Sprague rivers (see figure 1-1), which together provide about 75 percent of the drainage area to Upper Klamath Lake (table 3-10). The Sycan River, a major tributary to the Sprague, drains much of the northeastern portion of the watershed. Both the Williamson and Sprague subbasins are primarily forested and are largely within the Winema and Fremont National Forests, with some areas of shrub and grassland, agriculture, and wetland. The Wood River drains an area northeast of Upper Klamath Lake extending from the southern base of the eastern slopes of the Cascade Mountains near Crater Lake to its confluence with the northern arm of Upper Klamath Lake, which is often referred to as Agency Lake. Although primarily forested, the Wood River watershed also contains extensive agricultural lands and wetlands. The balance of the water reaching Upper Klamath Lake is derived from direct precipitation and flows from springs, small streams, irrigation canals, and agricultural pumps.

Table 3-10. Average flows in the Upper Klamath Lake and Keno reservoir area. (Source: PacifiCorp, 2004a; PacifiCorp, 2005f, as modified by staff; Reclamation, 2006a, as modified by staff; and USGS, 2006a, as modified by staff)

Location (gage number)	Drainage Area (square miles)	Mean Annual Flow (acre-feet x 1,000)	Mean Annual Flow (cfs)	River Mile
Williamson River gage (11502500)	3,000	780[a]	1,079[a]	270
Reclamation A canal	NA	236[b]	327[b]	255
Link River dam/Upper Klamath Lake	3,800	812[b]	1,123[b]	282.3 to 254.3
East Side powerhouse	NA	435[b]	601[b]	253.7
West Side powerhouse	NA	81[b]	112[b]	253.3
Link River gage (11507500)	3,810	812[b]	1,123[b]	253.2
Lost River diversion channel	NA	30[b] 115[b]	41[b] 159[b]	249.5
North canal	NA	36[c]	50[c]	246
Klamath Straits drain	NA	82[c]	114[c]	240.5
Ady canal	NA	120[b]	166[b]	240.3
Keno reservoir	3,920[d]	1,139[b]	1,575[b]	253.1 to 233

[a] USGS, 2006a (WY 1963-2004).
[b] PacifiCorp, 2005f (1/2/1990 - 12/5/2004).
[c] Reclamation, 2006a (1/2/1990 through 12/5/2004).
[d] Does not include Lost River.

Upper Klamath Lake and Link River Dam

Upper Klamath Lake is a large and relatively shallow natural lake with a mean depth of only 9 feet. Link River dam, owned by Reclamation and operated by PacifiCorp under Reclamation management directive, was constructed at the natural bedrock ledge-controlled outlet of Upper Klamath Lake in 1921. During construction, the bedrock ledge at the outlet area was removed to allow the lake to be drawn down about 3 feet lower than the natural elevation of 4,140.0 feet, resulting in a maximum range of water level variation of about 6 feet, between elevations 4,137 and 4,143 feet. Substantial drainage of the surrounding marshes for agricultural production has occurred in the last hundred years resulting in a present surface area of about 67,000 acres. The added available range in water levels increased the storage capacity to the present active storage of 486,830 acre-feet and a total storage of 629,780 acre-feet.

Reclamation manages water levels within Upper Klamath Lake to ensure that lake levels do not recede lower than the average end-of-month elevations that occurred between October 1990 and September 30, 1999, in accordance with the 2002 BiOps (FWS, 2002a; NMFS, 2002) for Reclamation's 10-year operating plan (Reclamation, 2002). This water level management regime and associated operational plan was developed to protect the federally listed Lost River and shortnose suckers and to enable seasonal minimum flows to be released downstream of Iron Gate dam that would be protective of federally listed coho salmon, discussed further in sections 3.3.3, *Aquatic Resources*, and 3.3.5, *Threatened and Endangered Species*. Lake levels are divided into water year-based rule curves defined by predicted inflow to Upper Klamath Lake 9 (table 3-11). Figure 3-6 shows historical (before construction of Link River dam) and recent water levels.

Table 3-11. Reclamation's Upper Klamath Lake operational plan per water year type. (Source: Reclamation, 2005b)

	Water year type, predicted inflow to Upper Klamath Lake, and end of month lake levels (USGS datum)			
	Above Average (more than 500,000 acre-feet)	**Below Average (between 500,000 and 312,000 acre-feet)**	**Dry (between 312,000 and 185,000 acre-feet)**	**Critical Dry (less than 185,000 acre-feet)**
October 31	4,139.7	4,138.8	4,138.2	4,137.3
November 30	4,140.3	4,139.0	4,139.0	4,138.1
December 31	4,141.0	4,138.8	4,139.7	4,138.9
January 31	4,141.5	4,139.5	4,140.3	4,140.1
February 28	4,141.9	4,141.7	4,140.4	4,141.1
March 31	4,142.5	4,142.7	4,141.7	4,142.0
April 30	4,142.9	4,142.8	4,142.2	4,141.9
May 31	4,143.1	4,142.7	4,142.4	4,141.4
June 30	4,142.6	4,142.1	4,141.5	4,140.1
July 31	4,141.5	4,140.7	4,140.3	4,138.9
August 31	4,140.5	4,139.6	4,139.0	4,137.6
September 30	4,139.8	4,138.9	4,138.2	4,137.1

Water flows from Upper Klamath Lake either through the Reclamation A canal (described in more detail below), PacifiCorp's East and West Side development canals, or through Link River dam. Flows from the East and West Side powerhouses are released back into the Link River 0.6 and 1.0 miles, respectively, downstream of Link River dam. Near this location, Link River enters the upper reaches of Keno reservoir. Table 3-12 shows monthly discharge statistics for the East and West Side powerhouses based on the available daily flow data for these powerhouses and the Link River immediately downstream of West Side powerhouse. USGS operates a real-time gage (no. 11507500, Link River at Klamath Falls, Oregon) slightly below the discharge of the East Side powerhouse. Table 3-13 provides the minimum flow and ramping rates for Link River dam as established in the 2002 BiOp (FWS, 2002a).

Klamath Irrigation Project

Reclamation's Klamath Irrigation Project (see figure 2-4) developed substantial water storage and distribution systems and drainage of lakes and wetlands, and it currently includes about 240,000 acres of irrigable lands. There are about 150,000 irrigated agricultural acres served by water withdrawn from the Upper Klamath Lake and the Klamath River. Reclamation states that, during a normal year, the net use of irrigation project water is 1.25 acre-feet per acre, including water used by FWS in the Tule Lake and Lower Klamath National Wildlife Refuges. The main sources of water for this system are Upper Klamath Lake via the A canal, the Klamath River from Keno reservoir, and the naturally closed Lost River Basin.

Table 3-14 provides a general summary of the dams and canals in the Klamath Irrigation Project, and table 3-15 shows monthly flow statistics for many of the Reclamation canals. According to Reclamation, it obtained water rights for the Klamath Irrigation Project in accordance with California and Oregon State law, pursuant to the Reclamation Act of 1902. The priority date of the Klamath Irrigation Project water is generally 1905, with some rights dating back to 1878.

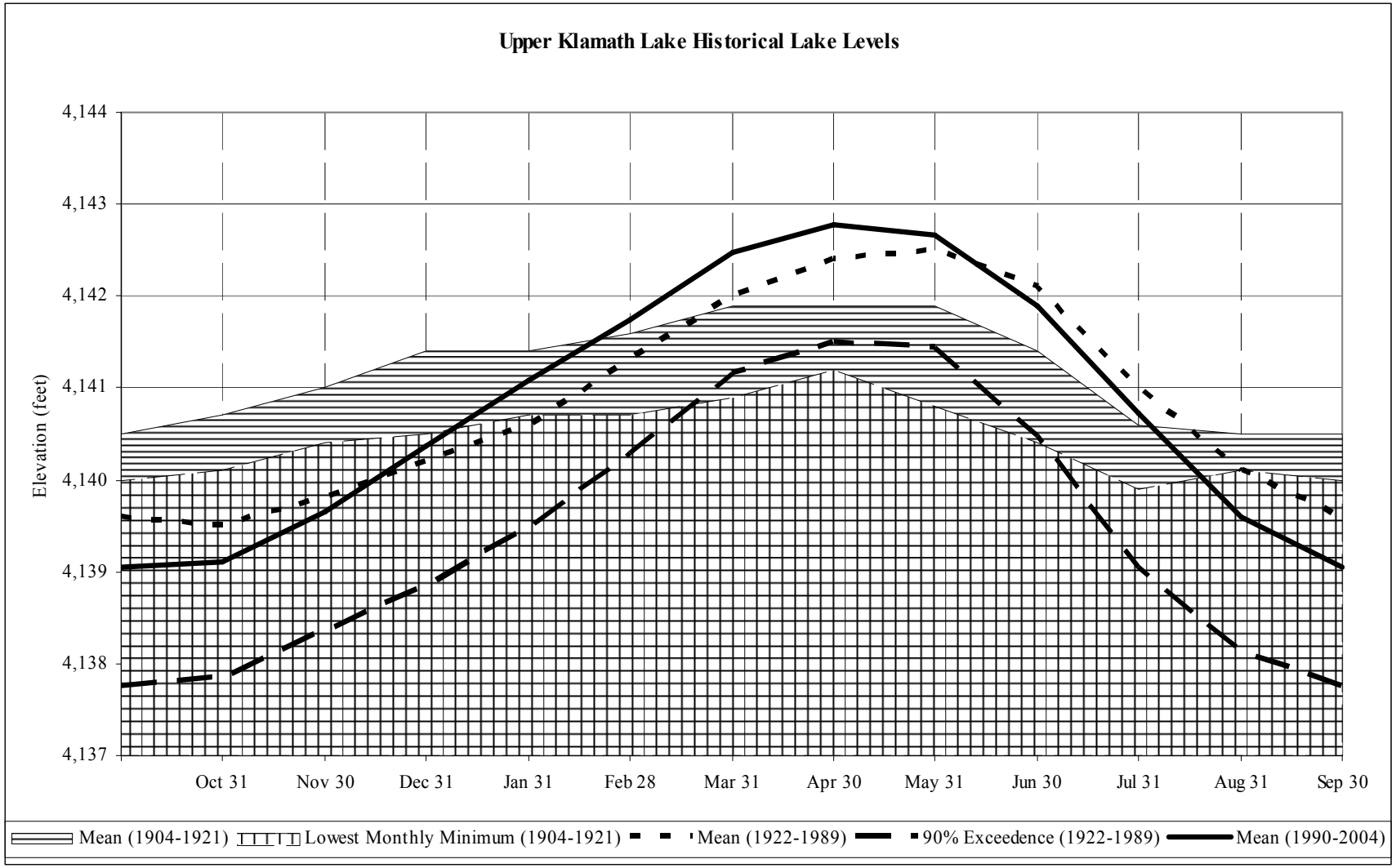


Figure 3-6. Upper Klamath Lake historical lake levels. (Source: Reclamation, 2005b; PacifiCorp, 2005f)

Table 3-12. Monthly discharge (cfs) statistics for East Side and West Side powerhouses and Link River downstream of the East Side powerhouse for January 2, 1990, through December 5, 2004. (Source: PacifiCorp, 2005f)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
East Side powerhouse													
Mean	590	552	602	639	522	531	693	585	729	635	608	523	601
Median	650	570	570	650	468	520	745	595	750	595	561	504	596
Max.	1179	1242	1357	1310	1155	1170	1310	1200	1500	1310	1420	1349	1500
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	964	930	1039	1060	1013	980	1040	1023	1048	991	1000	987	1015
90% Exceed.	120	150	150	150	120	0	204	120	312	289	250	120	150
West Side powerhouse													
Mean	78	122	140	121	101	95	129	130	152	138	81	65	113
Median	0	115	230	202	7	0	230	230	230	220	0	0	100
Max.	258	256	410	230	230	230	230	230	256	256	264	272	410
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	230	230	230	230	230	230	230	230	230	230	230	230	230
90% Exceed.	0	0	0	0	0	0	0	0	0	0	0	0	0
Link River, USGS gage no. 11507500													
Mean	769	746	945	1,420	1,397	1,572	1,612	1,443	1,157	863	832	732	1,124
Median	738	712	817	889	702	1,010	1,187	1,136	1,052	837	813	748	854
Max.	1,343	2,053	2,518	6,986	6,046	6,674	6,261	5,254	6,325	2,107	1,794	1,459	6,986
Min.	113	200	195	113	89	83	191	175	247	275	258	130	83
10% Exceed.	1,079	1,072	1,722	2,742	3,502	3,984	3,485	3,171	1,711	1,214	1,181	1,113	2,181
90% Exceed.	502	456	458	384	198	126	563	345	565	539	504	364	396

Table 3-13. Minimum flow and ramping rates for Link River dam. (Source: PacifiCorp, 2004a)

Location	Minimum Flow Information
Immediately below Link River dam	90 cfs but 250 cfs during the summer when water quality is adverse as per the FWS 2002 BiOp on suckers
Downstream of West Side powerhouse	450 cfs
Flow Rates (cfs)	**Link River Dam Ramping Rates**
0 to 300	20 cfs per 5 minutes
300 to 500	50 cfs per 30 minutes
500 to 1,500	100 cfs per 30 minutes

Table 3-14. General information on dams and canals within the Klamath Irrigation Project. (Source: Reclamation, 2006a)

Structure	Location	Storage (acre-feet)	Description
Link River dam	Outlet of Upper Klamath Lake	629,780	Regulates water surface levels in Upper Klamath Lake and flows in the Link River.
A canal	On Upper Klamath Lake above Link River dam	NA	Capacity of 1,150 cfs, conveys irrigation water from Upper Klamath Lake to irrigate about 63,000 acres.
Clear Lake dam and reservoir	Upper Lost River	527,000	Provides storage for irrigation and flow reduction.
Malone diversion dam	Lost River, 11 miles below Clear Lake dam	limited	Diverts water to agricultural lands along the Lost River in the Langell Valley.
Gerber dam and reservoir	Miller Creek a tributary to the Lost River below Malone dam	94,300	Provides storage for irrigation and reduces flow into the reclaimed portions of Tule Lake and the Tule Lake Sumps in the Tule Lake National Wildlife Refuge.
Lost River diversion dam	Lost River	2,300	Diverts water to the Klamath River through the Lost River diversion channel to control water reaching the Tule Lake area.
Anderson Rose diversion dam	Lost River	limited	Diverts water to agricultural lands near Tule Lake.
Lost River diversion channel	Lost River diversion dam to the Klamath River	NA	Diverts water from the Klamath River to the Lost River diversion dam. The canal is about 8 miles long and has a capacity of 3,000 cfs. During the irrigation season, the flow is generally from the Klamath River to supply irrigation water to agricultural areas near Tule Lake. During the winter the flow is generally from the Lost River diversion dam to the Klamath River, limiting flooding of the Tule Lake agricultural lands.
North canal	Klamath River	NA	Conveys water from the Klamath River and provides water for the irrigation of about 10,000 acres. Maximum capacity is about 300 cfs
Klamath Straits drain	Klamath River	NA	Conveys drainage water from the Lower Klamath National Wildlife Refuge and irrigated agricultural lands reclaimed from Lower Klamath Lake to the Klamath River. The drain is about 20 miles long and has a capacity of 600 cfs.
Ady canal	Klamath River	NA	Diverts water from the Klamath River to provide irrigation for about 15,000 acres in the Lower Klamath Lake area. Ady canal has a maximum capacity of about 1,050 cfs.

Table 3-15. Monthly discharge (cfs) statistics for canals in the Klamath Irrigation Project area for January 2, 1990, through December 5, 2004. (Source: PacifiCorp, 2005f, as modified by staff; Reclamation, 2006a, as modified by staff)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Reclamation A canal (PacifiCorp daily database)													
Mean	170	0	0	0	0	1	286	579	702	809	790	558	327
Median	0	0	0	0	0	0	238	610	755	880	818	610	70
Max.	635	5	0	0	0	80	830	955	1,025	1,055	1,005	965	1,055
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	495	0	0	0	0	0	640	870	925	995	940	780	870
90% Exceed.	0	0	0	0	0	0	0	235	340	489	635	80	0
To Lost River diversion channel (PacifiCorp daily database)													
Mean	3	1	0	1	1	5	28	53	132	156	101	15	42
Median	0	0	0	0	0	0	0	0	70	88	63	0	0
Max.	99	52	0	52	68	160	304	492	657	642	605	265	657
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	0	0	0	0	0	0	105	207	375	421	256	62	142
90% Exceed.	0	0	0	0	0	0	0	0	0	0	0	0	0
From Lost River diversion channel (PacifiCorp daily database)													
Mean	116	77	124	254	337	409	229	152	52	4	29	138	159
Median	102	71	103	142	157	174	75	9	0	0	0	85	69
Max.	755	580	1,164	3,008	2,945	2,805	2,051	2,724	1,324	197	531	1,066	3,008
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	245	132	221	655	989	1,298	502	348	131	0	95	304	343
90% Exceed.	0	0	38	47	49	19	0	0	0	0	0	0	0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
North canal (Reclamation daily database)													
Mean	28	31	63	73	40	22	26	39	70	91	65	51	50
Median	8	4	31	46	12	9	15	38	75	95	66	47	38
Max.	226	265	258	261	296	211	163	129	160	300	149	139	300
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	79	123	170	184	126	61	71	81	115	137	97	99	120
90% Exceed.	0	0	0	0	0	0	0	0	0	33	30	0	0
Klamath Straits drain (Reclamation daily database)													
Mean	31	46	63	111	195	249	160	161	130	79	82	64	114
Median	26	28	38	61	154	220	134	170	129	88	71	58	88
Max.	121	320	351	503	595	592	592	475	338	215	300	254	595
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	73	118	188	324	449	484	294	267	208	133	192	115	259
90% Exceed.	0	0	0	17	28	100	46	50	25	8	13	0	8
To Ady canal (PacifiCorp daily database)													
Mean	140	127	191	217	157	114	105	117	204	229	204	183	166
Median	139	123	161	178	138	109	102	121	215	239	201	188	158
Max.	457	499	637	656	1,062	430	375	379	537	499	428	387	1,062
Min.	0	0	0	0	0	0	0	0	0	0	21	0	0
10% Exceed.	259	266	381	438	308	201	223	232	308	344	300	283	307
90% Exceed.	12	6	0	62	0	11	0	0	79	87	114	63	11

Before development of the Klamath Irrigation Project, the surface area of Lower Klamath Lake was often larger than Upper Klamath Lake. Flows from the Klamath River, supplemented by springs around the lake, supported a complex of wetlands and open water covering about 80,000 to 94,000 acres in the spring, during high water, and 30,000 to 40,000 acres in late summer. By 1924, however, development of the Klamath Irrigation Project eliminated more than 90 percent of its open water and marsh. Only about 4,700 acres of open water and wetland remain. Connections between the Klamath River and Lower Klamath Lake were severed by development, which changed the hydrology of both the lake and the river. Current connectivity between Lower Klamath Lake and the rest of the basin is limited to water pumped from Tule Lake and water from irrigation structures that lead to and from the present day Keno reservoir.

Before the Klamath Irrigation Project, Tule Lake varied in surface area from 55,000 to more than 100,000 acres, averaging about 95,000 acres, at times larger than the former expanse of Upper Klamath Lake. Lost River was the main source of water to Tule Lake. Similar to Lower Klamath Lake, Tule Lake was connected seasonally to the Klamath River. During periods of high runoff, water from the Klamath River flowed into the Lost River slough and down the Lost River to Tule Lake. The direction of the river's flow is now determined by operators of the Klamath Irrigation Project depending on water needs. Most of the former bed of Tule Lake has been drained for agriculture, leaving about 9,450 to 13,000 acres of shallow lake and marshland.

Water Bank

The NMFS BiOp (NMFS, 2002) required Reclamation to establish a water bank to facilitate providing flows during critical times of the year for endangered coho salmon in the Klamath River downstream of the Klamath Irrigation Project and Iron Gate dam. Reclamation meets the water bank requirements with water storage, paying farmers to idle normally farmed land, and substituting groundwater for agricultural irrigation needs instead of Reclamation-supplied surface water. Some water can be stored in Upper Klamath Lake for the water bank, but this is not always possible during drought years and there are some conflicts with the requirements of the 2002 FWS BiOp, which governs water levels in Upper Klamath Lake for the endangered suckers. The primary methods that Reclamation uses to meet the water bank requirements are land idling and groundwater substitution. Storage volume requirements of the water bank were 50,000 acre-feet in 2003, 75,000 acre-feet in 2004, and 100,000 acre-feet in 2005 and until March 2011. Table 3-16 summarizes how the first three years of the water bank requirements were met.

Table 3-16. Water bank summary for 2003 through 2005. (Source: Reclamation, 2006b)

Year	Water Bank Requirement (acre-feet)	Idled land (acres)	Groundwater substitution	Other means	Total Water Bank volume supplied (acre-feet)
2003	50,000	14,400	11,000 acres	NA	59,000
2004	75,000	4,400	6,900 acres	Water purchased from groundwater suppliers	81,000
2005	100,000	25,600	13,900 acre-feet; acres not available.	50,000 acre-feet of water from groundwater suppliers and 15,000 acre-feet of storage in the Lower Klamath National Wildlife Refuge	118,738

By March 31 each year, NMFS and Reclamation determine the water distribution and release periods that will be used for the water bank storage volume. These releases require project coordination due to the interconnection of the Klamath Irrigation Project and the mainstem dams and reservoirs of the

Klamath Hydroelectric Project. See our later discussion on Iron Gate dam for further information on how the water bank volumes have been used in 2003 through 2005.

Keno Reservoir and Reach

Keno reservoir is shallow and long (table 3-17) and receives most of its water from Upper Klamath Lake via Link River. Keno reservoir also loses and receives a substantial amount of water from the Lost River diversion channel, North canal, Klamath Straits drain, and the Ady canal (figure 3-7). PacifiCorp is required by the Commission, in accordance with a 1965 license amendment, to operate Keno reservoir in accordance with an agreement with Reclamation that specifies that the maximum water surface elevation should be at 4,086.5 feet and the minimum water surface elevation should be at 4,085 feet. However, at the request of irrigators, PacifiCorp generally operates Keno dam to maintain the reservoir at elevation 4,085.4 +/-0.1 foot from October 1 to May 15 and elevation 4,085.5 +/-0.1 foot from May 16 to September 30 (figure 3-8) to allow consistent operation of irrigation canals and pumps. In addition, stable reservoir levels on a year-round basis help ensure functioning of the Lost River diversion channel and other canals. The occasional 2-foot drawdowns shown in figure 3-8 are generally implemented to allow irrigators to clean out their water withdrawal systems before the irrigation season. According to the Oregon Water Resources Department, in addition to the larger Reclamation diversions, there are numerous much smaller water permits and claims along Keno reservoir extending to the J.C. Boyle reservoir, mostly for irrigation on adjacent privately owned agricultural lands. Flows released from Keno dam to the Keno reach, as measured at USGS gage no. 11509500, about 2.5 miles downstream of the dam, are shown in table 3-18.

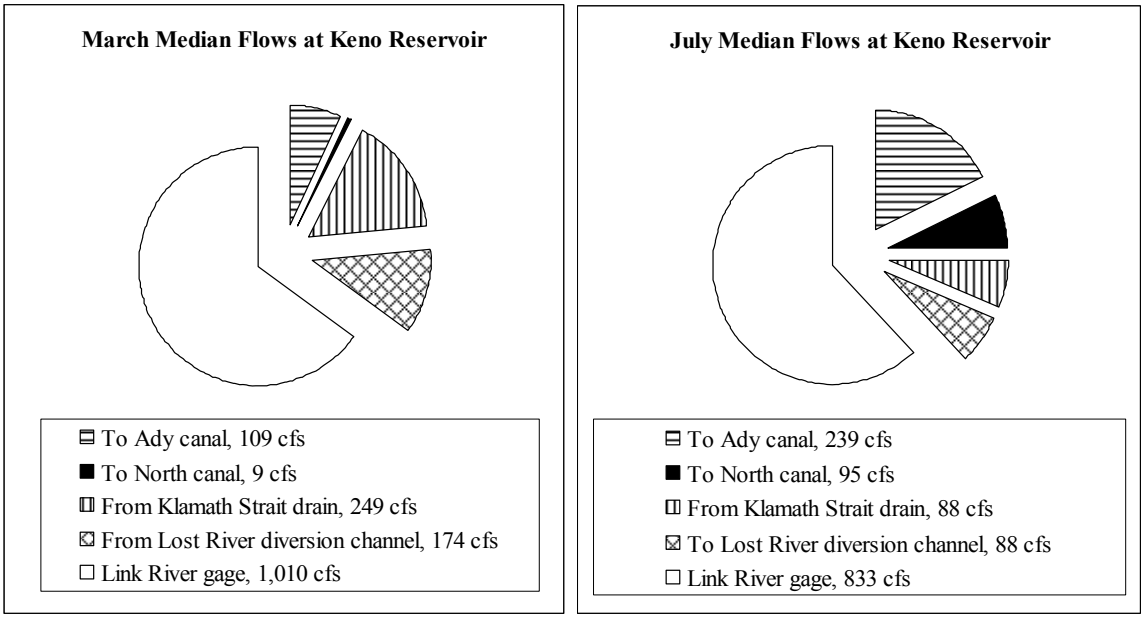


Figure 3-7. Keno reservoir March and July median inflows and outflows upstream of Keno dam. (Source: Reclamation, 2006a; PacifiCorp, 2005f)

Table 3-17. Reservoir area, inflow, storage, and retention[a] times. (Source: PacifiCorp, 2004a; USGS, 2006a)

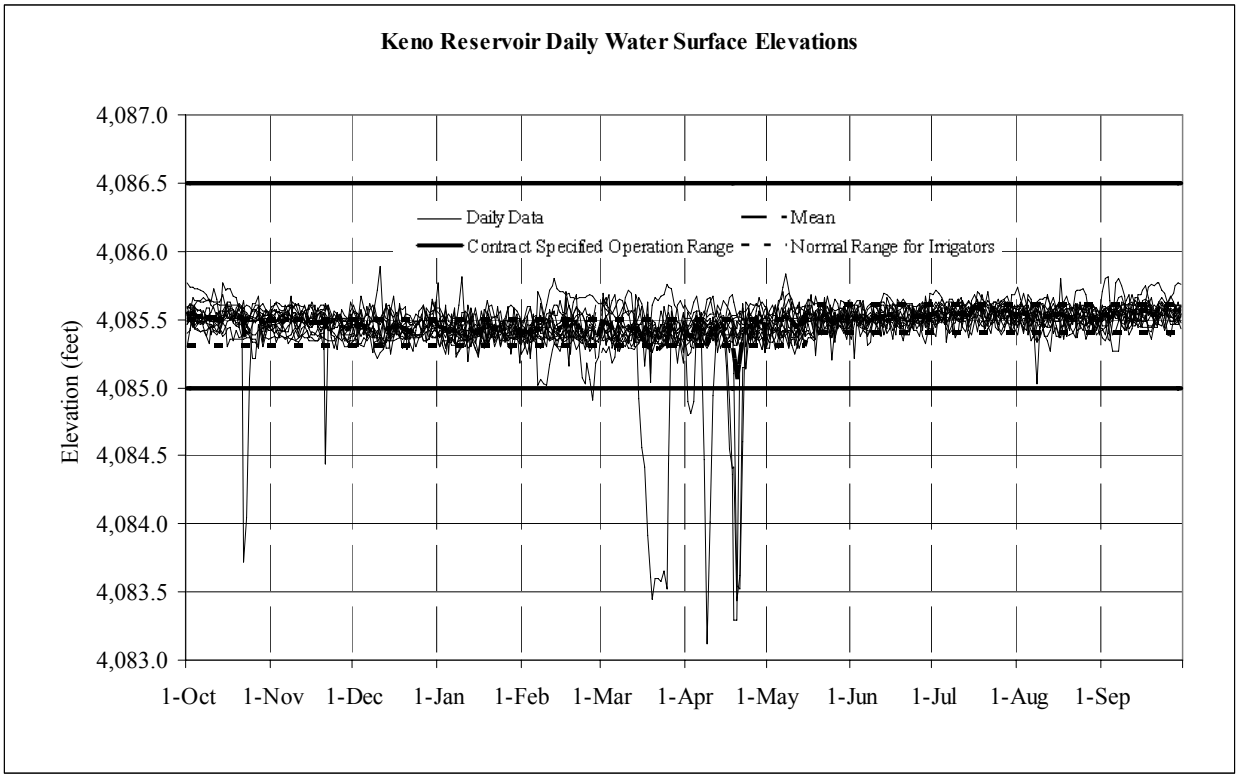
Reservoir	Surface Area (acres)	Average Yearly Inflow (cfs)	Average Depth (feet)	Maximum Depth (feet)	Active Storage[b] (acre-feet)	Total Storage[b] (acre-feet)	Retention Time (days)
Upper Klamath Lake	67,000	1,450	9	60	486,830	629,780	219
Keno	2,475	1,575	7.5	20	495	18,500	5.9
J.C. Boyle	420	1,575	8.3	40	1,724	3,495	1.1
Copco	1,000	1,585	47	108	6,235[d]	33,724	10.7
Copco No. 2	40	1,585	[c]	[c]	0	73	0.0
Iron Gate	944	1,733	62	167	3,790[d]	50,941	14.8

[a] Retention time is storage divided by average yearly inflow.

[b] Storage volumes are from table A2.1-1 of PacifiCorp's exhibit A. These values appear to be the most recent values and contain the updated storage volumes based on recent bathymetric surveys for Copco reservoir and Iron Gate reservoir.

[c] Very small reservoir, no information on depth provided.

[d] Storage for Copco reservoir between the normal maximum water level and the invert of the penstock intakes is approximately 20,000 acre-feet. Storage for Iron Gate reservoir between the normal maximum water level and invert of the penstock intake is approximately 24,000 acre-feet.



Note: Data for January 2, 1990, to December 5, 2004.

Figure 3-8. Keno reservoir daily water surface elevations. (Source: PacifiCorp, 2005f)

Table 3-18. Monthly discharge (cfs) statistics in the Klamath Project area. (Source: USGS, 2006a)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Klamath River at Keno, OR, USGS gage no. 11509500 (water years 1963 to 2004). Drainage area, 3,920 square miles, excluding Lost River.													
Mean	1,250	1,620	2,040	2,249	2,385	2,849	2,279	1,552	733	431	639	919	1,575
Median	1,050	1,300	1,775	1,920	2,110	2,165	1,750	1,070	440	376	676	942	1,020
Max.	4,210	5,210	8,160	9,310	9,250	9,780	8,000	6,640	6,640	2,750	1,350	2,240	9,780
Min.	268	292	300	251	184	200	203	201	147	131	144	145	131
10% Exceed.	2,360	2,691	3,770	4,090	4,978	6,339	4,982	3,479	1,451	692	885	1,381	3,250
90% Exceed.	621	620	721	631	480	514	571	395	275	252	322	462	348
Klamath River below J.C. Boyle powerhouse, USGS gage no. 11510700 (water years 1963 to 2004). Drainage area, 4,080 square miles, excluding Lost River.													
Mean	1,499	1,856	2,228	2,403	2,541	2,899	2,516	1,901	1,061	678	880	1,165	1,767
Median	1,390	1,540	2,010	2,000	2,285	2,380	2,160	1,450	738	656	939	1,190	1,280
Max.	4,170	5,100	8,260	9,860	10,200	9,630	7,810	6,790	6,740	1,890	1,650	2,290	10,200
Min.	320	355	342	318	316	313	306	317	321	309	302	309	302
10% Exceed.	2,520	2,850	3,600	3,912	5,333	6,120	5,034	3,860	1,921	985	1,176	1,600	3,430
90% Exceed.	855	855	868	816	646	691	760	630	495	385	502	700	566
Fall Creek near Copco, CA, USGS gage no. 11512000 (water years 1933 to 1959). Drainage area, 15 square miles.													
Mean	35	37	43	46	51	49	45	38	35	34	33	34	40
Median	34	36	37	40	45	46	44	36	33	33	32	33	36
Max.	77	137	474	249	200	130	187	65	58	52	47	52	474
Min.	27	26	28	28	27	29	28	25	24	24	24	24	24
10% Exceed.	44	45	57	65	75	69	61	49	44	42	43	44	55
90% Exceed.	28	30	30	30	31	32	31	29	28	28	27	28	29
Klamath River below Iron Gate dam, CA, USGS gage no. 11516530 (water years 1963 to 2004). Drainage area, 4,630 square miles, excluding Lost River													
Mean	1,601	2,028	2,615	2,938	3,097	3,621	2,995	2,158	1,153	791	969	1,268	2,098
Median	1,370	1,750	1,965	2,490	2,650	2,860	2,370	1,685	796	733	1,020	1,330	1,380
Max.	4,550	5,830	25,000	18,500	16,100	16,200	12,500	6,950	7,710	3,570	1,650	2,500	25,000
Min.	846	848	865	598	508	495	508	484	402	406	389	408	389
10% Exceed.	2,729	3,260	4,508	5,478	5,948	7,439	5,883	4,298	1,990	1,040	1,080	1,691	4,220
90% Exceed.	944	918	1,290	1,290	918	960	1,020	1,010	708	672	696	835	725

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J.C. Boyle Reservoir

PacifiCorp states J.C. Boyle reservoir is operated within a range of 5.5 feet[53] from full pond and that daily fluctuation from peaking operations at the J.C. Boyle powerhouse is generally between 1 and 2 feet. This reservoir is relatively small (420 acres) and inflow is retained for a comparatively short amount of time (see table 3-17). Figure 3-9 shows the daily fluctuations for 1990 to 2005. Spillage at the dam typically occurs only when river flows exceed the capacity of the J.C. Boyle powerhouse and the low-flow requirements. As table 3-19 shows, spillage is rare except during the higher flow months of January through May.

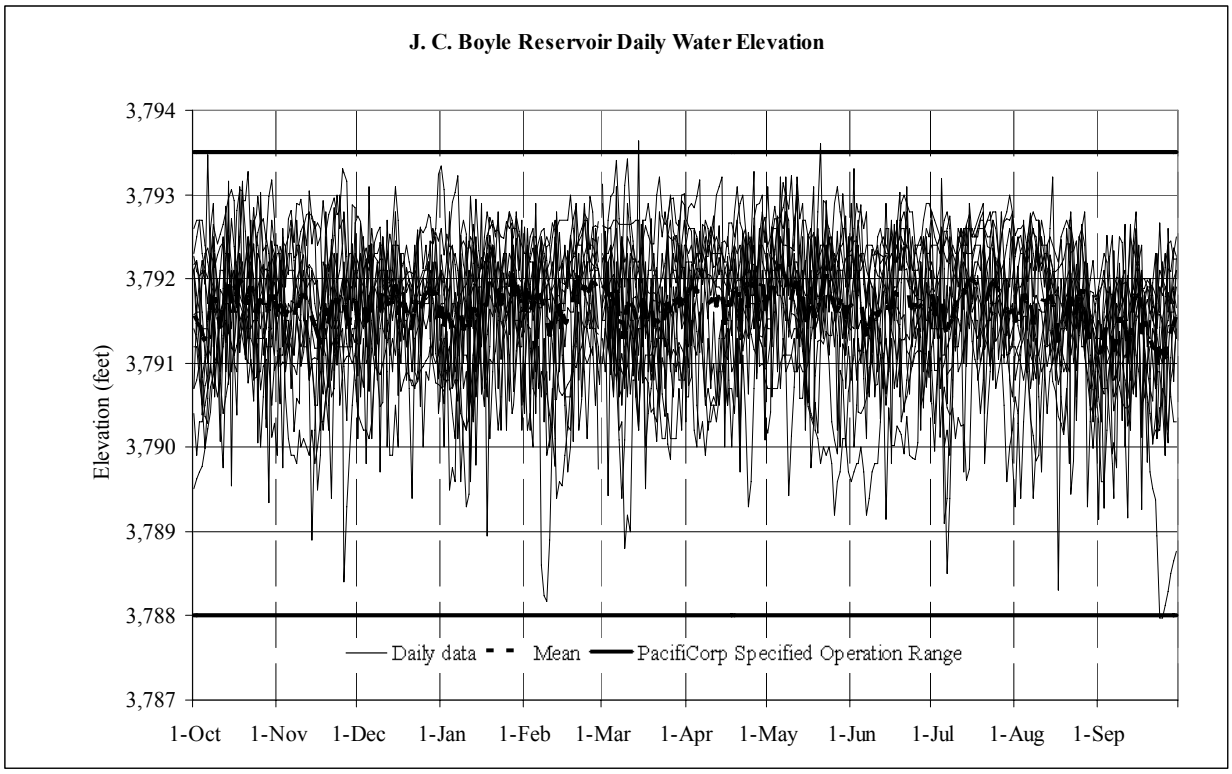


Figure 3-9. J.C. Boyle reservoir daily water surface elevations for January 2, 1990, to December 5, 2004. (Source: PacifiCorp, 2005f, as modified by staff)

J.C. Boyle Bypassed Reach

The 4.3-mile-long J.C. Boyle bypassed reach is a steep gradient section of the Klamath River from the dam to the powerhouse. Substantial groundwater enters the bypassed reach starting about 0.5 mile downstream of the dam. The average accretion in the bypassed reach is between 220 and 250 cfs and is relatively constant on a seasonal basis. Accretion estimates are measured through calculating the difference between the flow released from the dam (bypass pipe and fish ladder) and the USGS gage downstream of J.C. Boyle powerhouse during non-generating periods.

[53]Table A2.1-1 of PacifiCorp's license application states 5 feet, and figure B9.6-1 of the application indicates 5.5 feet.

Table 3-19. Average spillage at J.C. Boyle, Copco No. 1, and Iron Gate dams for January 2, 1990, through December 5, 2004. (Source: PacifiCorp, 2005f, as modified by staff)

	J.C. Boyle			**Copco No. 1**			**Iron Gate**		
	Average # of days	**Average[a] (cfs)**	**Average Monthly Spill[b] (acre-feet)**	**Average # of days**	**Average[a] (cfs)**	**Average Monthly Spill[b] (acre-feet)**	**Average # of days**	**Average[a] (cfs)**	**Average Monthly Spill[b] (acre-feet)**
October	1.8	553	2,271	0.0	-	-	1.9	132	552
November	0.0	-	-	0.4	756	772	2.4	523	2,911
December	0.2	1,215	552	1.8	1,783	7,488	5.1	1,395	18,046
January	4.3	2,803	28,235	5.2	3,682	44,378	11.0	1,379	35,539
February	7.1	2,368	37,812	8.4	2,672	50,957	12.1	2,934	79,987
March	7.8	1,738	41,677	7.4	2,774	46,219	17.3	2,297	89,676
April	5.8	1,728	22,750	5.9	2,026	27,205	15.7	1,595	56,608
May	4.7	2,207	21,483	5.3	2,031	24,122	15.0	1,643	55,979
June	1.8	801	3,148	1.1	1,136	2,732	6.1	790	10,930
July	0.1	266	61	0.0	-	-	2.1	56	246
August	0.0	-	-	0.3	96	61	0.2	656	307
September	0.9	456	950	0.0	-	-	0.0	-	-
Yearly	35	2,032	161,272	36	2,506	206,834	89	1,726	352,196

Note: Most of water year 1993 is missing for this data set.

[a] Average flow during spill events.

[b] Includes non-spill events.

J.C. Boyle Peaking Reach

Monthly flow statistics for the peaking reach are shown in table 3-20. Under current operations, when inflow to J.C. Boyle reservoir is below 3,000 cfs, water is typically stored at night and flows during the day, the period of peak energy demand, are ramped up to either one unit operation (up to 1,500 cfs) or two unit operation (up to 3,000 cfs). According to PacifiCorp, the preferred flow through the powerhouse is 2,500 cfs due to turbine efficiencies, but as shown in table 3-20, this preferred flow is infrequently achieved on a daily average basis, during most months. When generation is not occurring and J.C. Boyle dam is not spilling, normal flows in the peaking reach are about 320 to 350 cfs, consisting of 80 cfs from the fish ladder, 20 cfs from the juvenile fish bypass system, and the rest from spring accretion in the bypassed reach. PacifiCorp states that because of the popularity of whitewater boating on the J.C. Boyle peaking reach, PacifiCorp considers the timing demands of commercial whitewater rafters as well as power demand, during May through mid October as discussed in greater detail in section 3.3.6, *Recreational Resources*. The current license requires a ramping rate of 9 inches per hour for both upramping and downramping. Figure 3-10 shows the July flows at USGS gage no. 11510700 Klamath River below J.C. Boyle powerhouse which is located at RM 219.7, about 0.7 mile downstream of the powerhouse, this type of a flow regime is typical in this reach during low flows. PacifiCorp has two direct diversion water rights along this reach for irrigation and stock watering at Copco ranch: 10 cfs and 2,300 acre-feet per year at the Owens ditch diversion and 5 cfs and 600 acre-feet per year at the Owens Island diversion, both of which are gravity-fed diversions along the river (letter from R. Kanz, California State Water Resources Control Board, to the Commission, dated January 20, 2005).

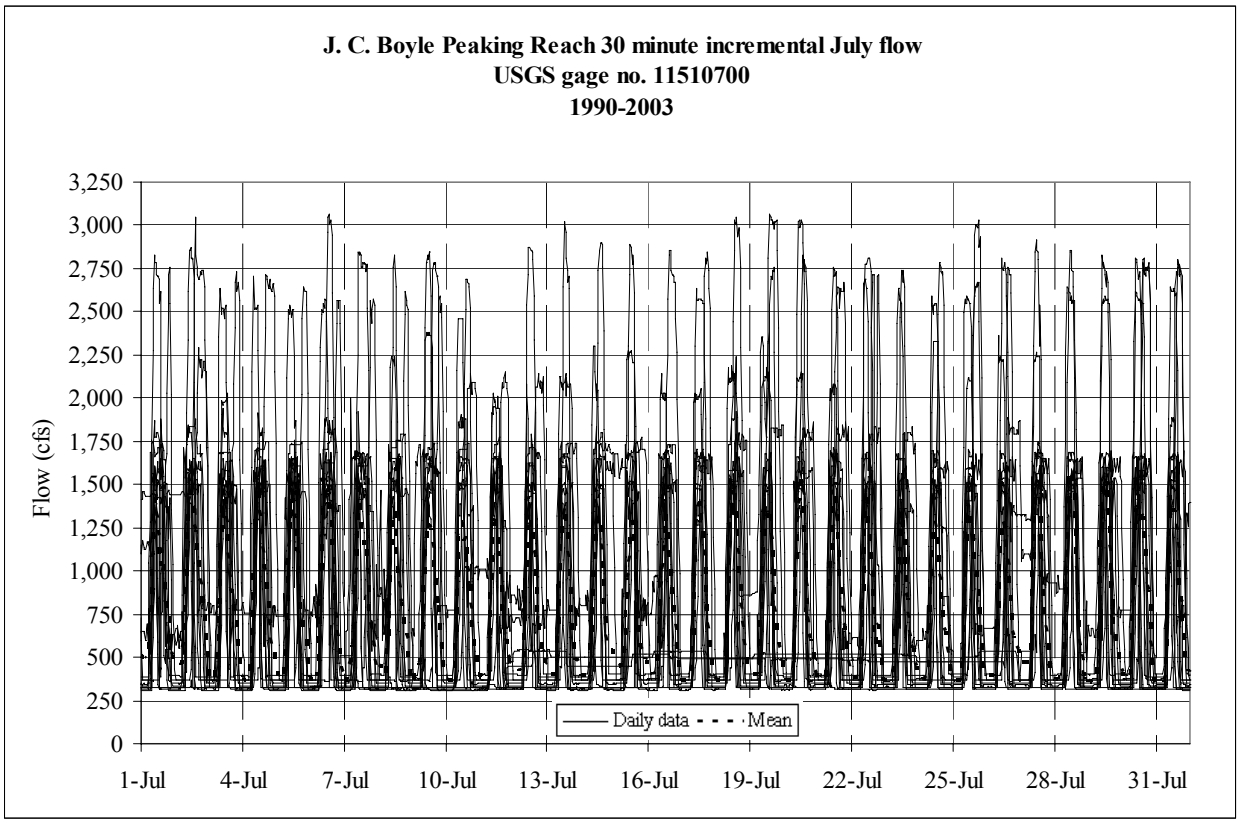


Figure 3-10. Klamath River flows (cfs) during July for the J.C. Boyle peaking reach for water years 1990 to 2004. (Source: USGS, 2005, as modified by staff)

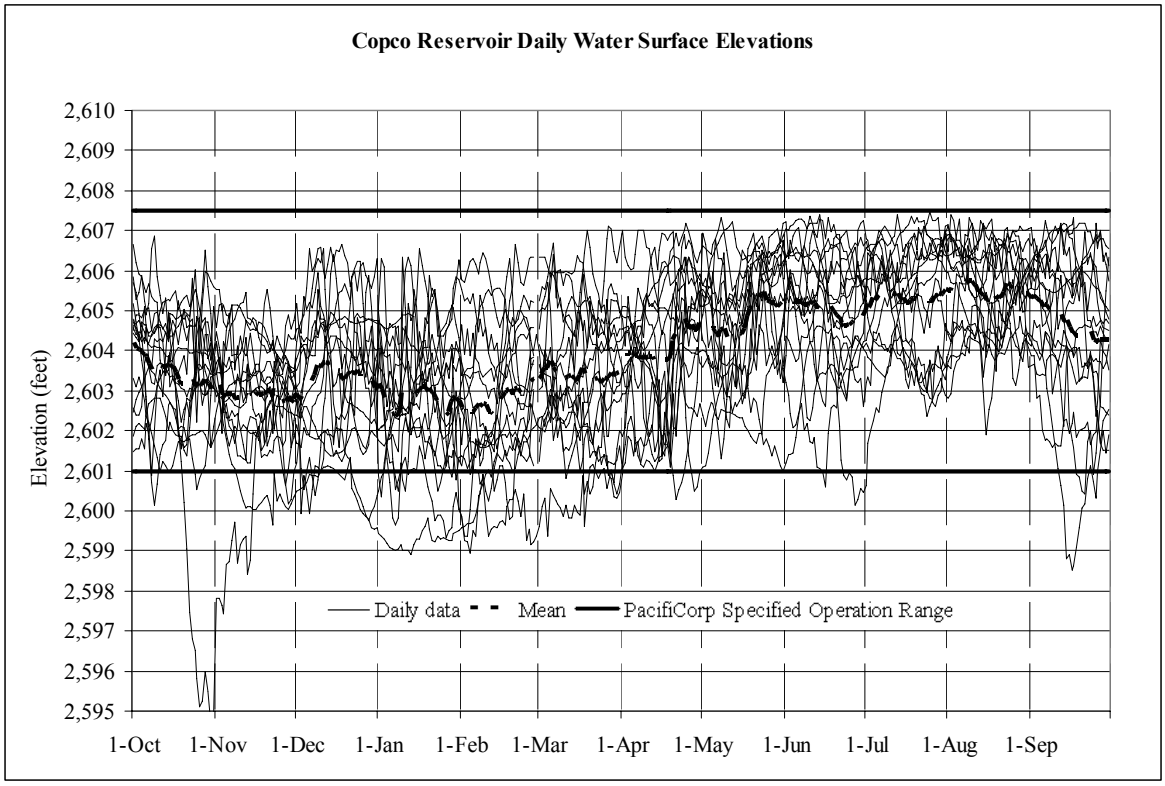
Table 3-20. Monthly discharge (cfs) statistics for J.C. Boyle, Copco No. 1, and Iron Gate powerhouses. (Source: PacifiCorp, 2005f, as modified by staff)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
J.C. Boyle powerhouse PacifiCorp daily database (Jan 2, 1990 to Dec 5, 2004)													
Mean	750	858	1,107	1,329	1,338	1,557	1,523	1,289	801	395	491	637	1,005
Median	831	850	861	968	952	1,659	1,435	1,134	647	378	556	606	759
Max.	1,698	2,929	2,949	2,996	2,978	2,965	3,016	3,023	2,665	1,328	1,094	1,433	3,023
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
10% Exceed.	1,109	1,303	2,322	2,806	2,933	2,862	2,873	2,547	1,552	715	791	1,046	2,535
90% Exceed.	334	428	433	403	200	185	232	190	179	0	129	232	216
Copco No. 1 powerhouse PacifiCorp daily database (Jan 2, 1990 to Dec 5, 2004)													
Mean	1,106	1,177	1,359	1,545	1,554	1,894	1,781	1,572	1,135	702	804	974	1,299
Median	1,182	1,209	1,232	1,329	1,271	1,972	1,690	1,430	988	671	847	976	1,124
Max.	2,111	3,205	3,225	3,238	3,266	3,356	3,247	3,179	3,167	1,482	1,672	2,116	3,356
Min.	289	316	128	101	264	0	0	0	0	0	0	0	0
10% Exceed.	1,448	1,688	2,258	2,957	3,100	3,063	3,040	3,018	1,990	1,096	1,136	1,336	2,864
90% Exceed.	714	718	761	712	514	493	553	459	450	380	436	563	548
Iron Gate powerhouse PacifiCorp daily database (Jan 1, 1993 to Dec 5, 2004)													
Mean	1,166	1,212	1,378	1,417	1,353	1,509	1,578	1,325	1,206	847	902	1,081	1,247
Median	1,218	1,207	1,503	1,610	1,545	1,669	1,676	1,624	1,184	765	962	1,180	1,227
Max.	1,703	1,799	1,801	1,868	1,963	2,481	1,784	1,796	1,755	1,330	1,245	1,736	2,481
Min.	629	0	642	630	316	607	604	30	30	269	554	689	0
10% Exceed.	1,314	1,703	1,711	1,722	1,737	1,765	1,768	1,728	1,712	1,064	1,053	1,314	1,720
90% Exceed.	850	814	835	865	823	812	1,264	565	735	607	608	843	725

Substantial tributaries in this reach include Rock Creek, at RM 213.9, and Shovel Creek at RM 206.5. Up to 15 cfs is currently diverted from Shovel Creek and Negro Creek (a tributary of Shovel Creek) for irrigation purposes by PacifiCorp during the summer.

Copco Reservoir

Copco reservoir is substantially deeper than the two upstream reservoirs (Keno and J.C. Boyle) with much greater total storage capacity (33,724 acre-feet) and active storage volume (6,235 acre-feet, the most active of all project reservoirs). PacifiCorp states that water levels in Copco reservoir are normally maintained within 6.5 feet from elevations 2,601.0 to 2,607.5 feet, and daily fluctuations in reservoir water levels of about 0.5 foot are due to peaking operation of the Copco No. 1 powerhouse and variance in the inflow from the J.C. Boyle peaking reach. Figure 3-11 shows daily water elevations for Copco reservoir for 1990 to 2004; the reservoir range is often lower than elevation 2,602.5 feet in winter months. Spillage at Copco No. 1 dam occurs most frequently during January through May (see table 3-17).



Note: Data for January 2, 1990, to December 5, 2004.

Figure 3-11. Copco reservoir daily water surface elevations. (Source: PacifiCorp, 2005f, as modified by staff)

Copco No. 2 Reservoir and Bypassed Reach

The Copco No. 1 powerhouse can discharge up to 3,560 cfs directly into the 0.25-mile-long Copco No. 2 reservoir. PacifiCorp states that since the Copco No. 2 reservoir has virtually no storage, the powerhouse (maximum hydraulic capacity of the flowline is 3,200 cfs) acts as a virtual slave to discharge from Copco reservoir and the water level within Copco No. 2 reservoir rarely fluctuates more than several inches. Spillage at Copco No. 2 dam would typically only occur when inflow exceeds the capacity of Copco No. 2 powerhouse, which occurs infrequently from November through April (see table 3-20).

There is a 1.5-mile-long bypassed reach between Copco No. 2 reservoir and powerhouse. There is currently no minimum flow requirement at this bypassed reach, but PacifiCorp states it normally releases 5 to 10 cfs via a 24-inch-diameter pipe at the dam. This pipe discharges onto downstream boulders, based on our observations during the May 19, 2004, site visit. PacifiCorp states that in the bouldered and steeply sloping bypassed reach, accretion adds very little natural flow, unlike the J.C. Boyle bypassed reach. Discharge from Copco No. 2 powerhouse enters the upper reaches of the Iron Gate reservoir.

Spring, Fall, and Jenny Creeks

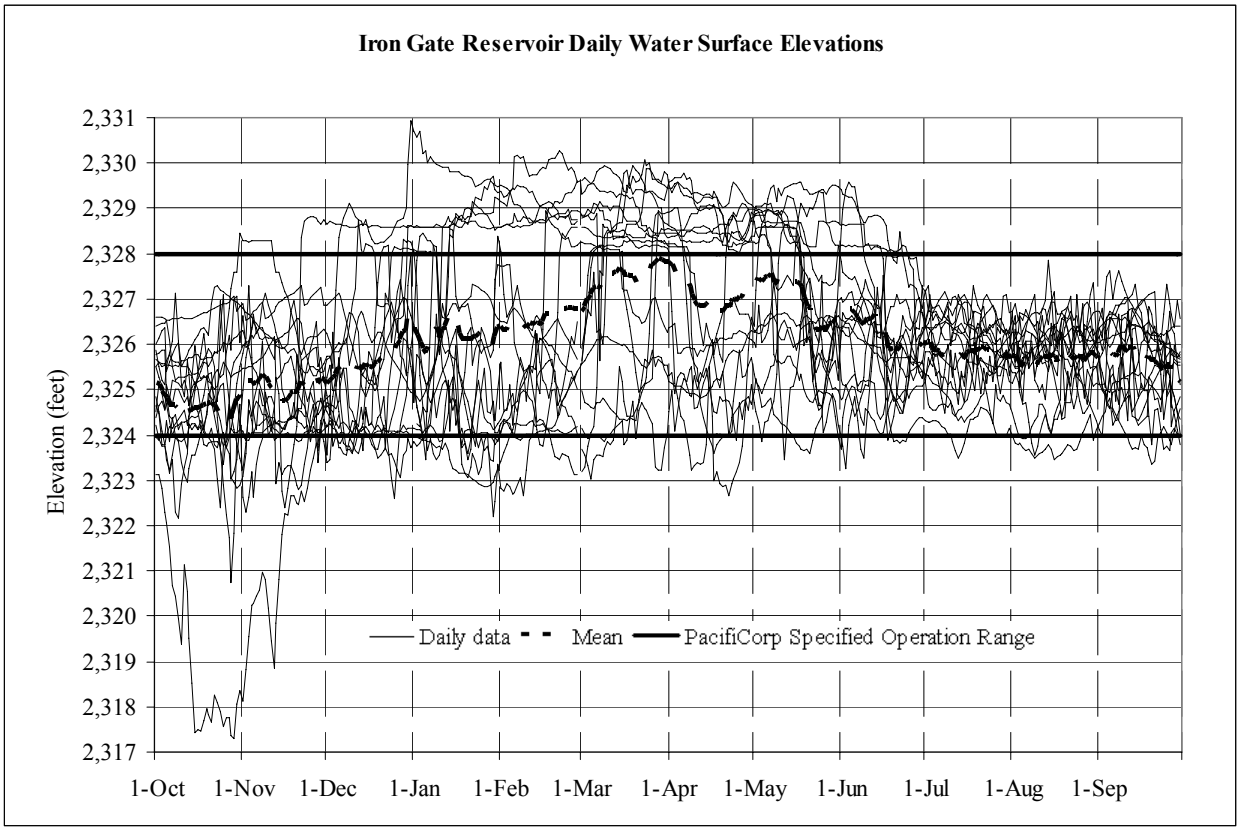
Two perennial tributaries, Jenny and Fall creeks, enter Iron Gate reservoir (see figure 2-6). As figure 2-7 shows, Spring Creek is a tributary to Jenny Creek, which flows for 1.2 miles from its source at Shoat Springs before it enters Jenny Creek at RM 5.5. Flow in Jenny Creek is altered by upstream reservoirs that are part of the Rogue River Irrigation Project that store water during the high runoff season for irrigation; about 30 percent of the mean annual runoff (24,000 acre-feet) of the Jenny Creek watershed is diverted north into the Rogue River Basin. PacifiCorp estimates that normally between 30 and 500 cfs enters Iron Gate reservoir from Jenny Creek.

PacifiCorp operates a small diversion dam on Spring Creek that diverts up to 16.5 cfs into Fall Creek, and another dam on Fall Creek that diverts flow into a canal and penstock system leading to the Fall Creek powerhouse (see figure 2-7). PacifiCorp states that the Spring Creek diversion was unusable for most of the 1990s, and until 2003, due to a water rights lawsuit with a local landowner, but that the lawsuit was decided in favor of PacifiCorp in 2003. The Spring Creek diversion is located 0.5 mile upstream of its confluence with Jenny Creek, and diverted flow is carried through a 1.3-mile-long canal where it enters Fall Creek about 1.7 miles upstream of the Fall Creek diversion. PacifiCorp estimates the minimum observed flow in Spring Creek as 5 cfs. The diversion dam on Fall Creek diverts up to 50 cfs of flow that bypasses 1.2 miles of a very steep gradient section of Fall Creek, leading to the Fall Creek powerhouse. The project's current license requires minimum flows of 0.5 cfs below the Fall Creek diversion and 15 cfs (or natural stream flow, whichever is less) downstream of the powerhouse.

USGS operated gage no. 11512000 on Fall Creek a short distance downstream of the Fall Creek powerhouse, the fish hatchery, and the city of Yreka intakes during most of 1933 to 1959; table 3-18 gives monthly and annual flow statistics. From October 1, 2003, until September 30, 2005, this gage was reactivated and, during this time, the gage recorded a mean flow of 40 cfs and a minimum flow of 21 cfs. According to data from this gage, flow within Fall Creek does not vary much seasonally due to a reliable baseflow from groundwater springs and typically ranges from 30 to 50 cfs. The city of Yreka, California, operates a water supply intake downstream of the Fall Creek powerhouse and has water rights to withdraw up to 15 cfs. This facility, which is the sole normal water supply for the city, consists of two small impoundments, an intake structure, a pump and treatment plant, a cathodic protection field, and distribution pipelines, including the 24-inch diameter transmission main (letter from R. McNeil, Mayor, city of Yreka, California, to the Commission, dated November 29, 2006). Intakes to the currently non-operating Fall Creek rearing facility are below the Yreka intake, and water rights include 10 cfs and 5,465 acre-feet per year between March 15 and December 15 for Cal Fish & Game and 10 cfs between June 1 to November 1 for PacifiCorp.

Iron Gate Reservoir

Iron Gate reservoir is the deepest project reservoir with the greatest total storage (50,941 acre-feet) (see table 3-17). The dam was constructed as a re-regulating facility to dampen the effects of the peaking operations of J.C. Boyle, Copco No. 1, and Copco No. 2 developments on the Klamath River. PacifiCorp states that water levels in Iron Gate reservoir are normally maintained within 4 feet of the full pond (elevation 2,328.0 feet) resulting in an active storage volume of 3,790 acre-feet. PacifiCorp notes that daily water level fluctuations within Iron Gate reservoir due to upstream peaking operations are about 0.5 foot. Figure 3-12 shows daily water levels at Iron Gate reservoir.



Note: Data for January 2, 1990 to December 5, 2004.

Figure 3-12. Iron Gate reservoir daily water surface elevations. (Source: PacifiCorp, 2005f, as modified by staff)

The Iron Gate powerhouse is located at the base of the dam and has a maximum hydraulic capacity of 1,735 cfs. The invert of the intake leading to the 12-foot-diameter Iron Gate penstock is at elevation 2,293 feet about 35 feet below the normal full pool elevation. Estimated monthly and annual flows through the powerhouse are shown in table 3-20. Water is also withdrawn from Iron Gate reservoir via a 30-inch-diameter pipe at an invert of 2,260 feet with a maximum direct diversion water right of 48 cfs to provide cool water to the Iron Gate Fish Hatchery, located about 0.25 mile downstream of the dam. There is a second hatchery intake at elevation 2,309 feet which PacifiCorp states is used infrequently.

USGS gage no. 11516530, Klamath River below Iron Gate dam, is a real-time gage with 15 minute interval data available at RM 189.6, about 0.5 mile downstream of Iron Gate dam. The flow recorded at this gage includes the contributions of the following sources:

- discharge from the Iron Gate powerhouse;
- spillage from Iron Gate dam;
- discharge water from the Iron Gate Fish Hatchery; and
- flow from Bogus Creek, a relatively small tributary to the Klamath River.

Figure 3-13 provides a long-term representation of yearly flow for water years 1963 to 2004. Data for the same period are summarized in table 3-18.

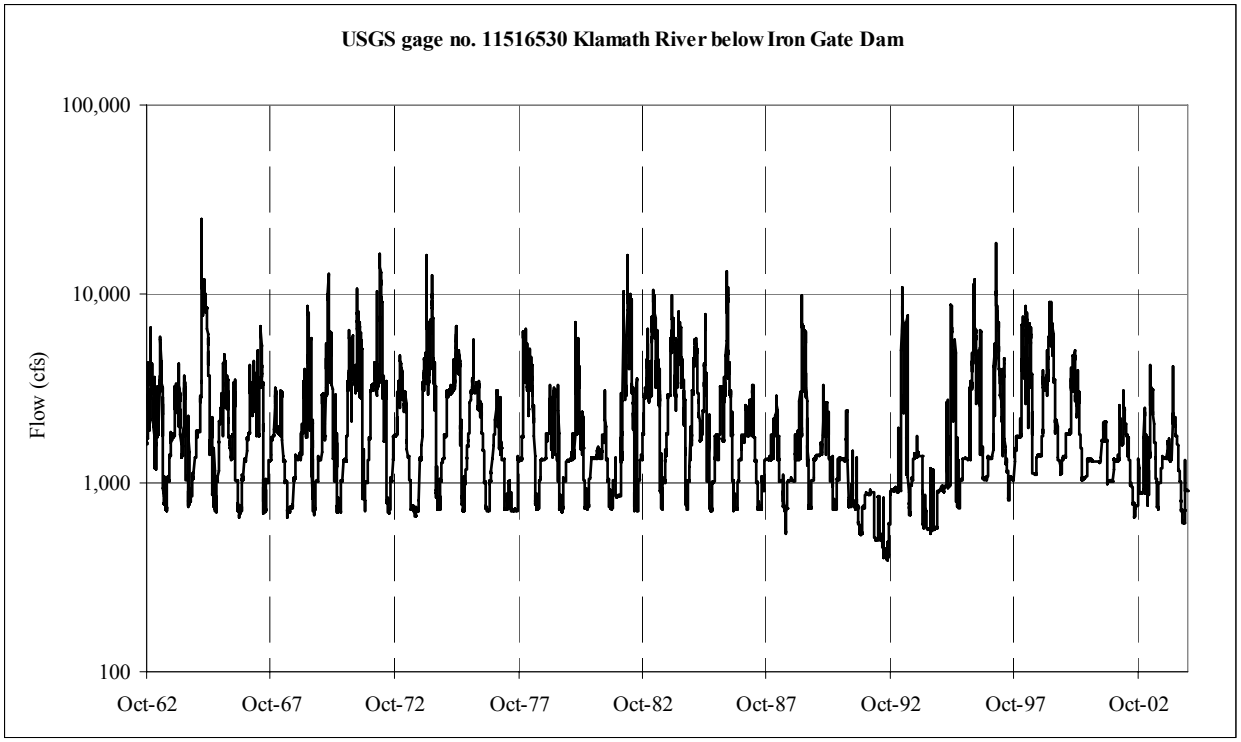


Figure 3-13. Flow below Iron Gate dam for water years 1963 to 2004. (Source: USGS, 2006a)

PacifiCorp uses data from USGS gage no. 11516530 to ensure and monitor compliance with a complicated set of flow criteria that apply to Iron Gate development, some of which are established by the existing license and others by the BiOps issued by NMFS to Reclamation for the operation of the Klamath Irrigation Project. Table 3-21 shows the ramping rate criteria for Iron Gate.

Table 3-21. Ramping rate requirements for Iron Gate dam. (Source: PacifiCorp, 2004a; staff)

Flow Range	Maximum Decrease	Source
General	250 cfs per hour or 3 inches per hour whichever is less	FERC 1961 license amendment
Above 1,750 cfs	not more than 125 cfs per 4 hour period and not exceeding 300 cfs per 24 hours	NMFS 2002
1,750 cfs or less	not more than 50 cfs per 2 hour period and not exceeding 150 cfs per 24 hour period	NMFS 2002

The current license (as amended in 1961) stipulates a minimum flow release of 1,300 cfs from September through April; 1,000 cfs in May and August; and 710 cfs in June and July. Since 1997, PacifiCorp has operated the development to provide flow releases based on Reclamation's annual operating plans. To comply with the recent (2002) BiOps for protecting the federally listed coho salmon (NMFS, 2002) and Lost River and shortnose suckers (FWS, 2002a), Iron Gate development is currently operated under a river flow release regime based on the projected water year type as determined on April 1 of each year (table 3-22).

Table 3-22. NMFS 2002 BiOp Iron Gate dam releases criteria based on water year. (Source: Reclamation, 2005b)

	Water Year Type and Flow (cfs)				
Time Step	**Wet**	**Above Normal**	**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	827	959	641
June 16-30	1,921	934	1,163	746	617
July 1-15	1,359	710	756	736	516
July 16-30	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 16-30	6,649	4,009	2,553	1,896	695

Reclamation Classification (Klamath Irrigation Project 2003 Operations Plan) for River Flow Planning	
Water Year Type	**Based on predicted Upper Klamath Lake Net Inflow (acre-feet) for April–September**
Wet	Above 785,2000
Above Average	785,200 to greater than 568,600
Average	568,500 to greater than 458,400
Below Average	458,300 to greater than 286,800
Dry	Less than 286,800

In addition, pursuant to the NMFS BiOp, Reclamation, in consultation with NMFS and FWS, develops a schedule to use storage from the water bank associated with the Klamath Irrigation Project to supplement flow releases at Iron Gate development as discussed previously. The storage volume requirements of the water bank and actual volumes supplied in 2003, 2004, and 2005, are shown in table 3-16. Figures 3-14 through 3-16 show how the water bank flows were used and the actual flows at the USGS gage downstream of Iron Gate dam in 2003, 2004, and 2005.

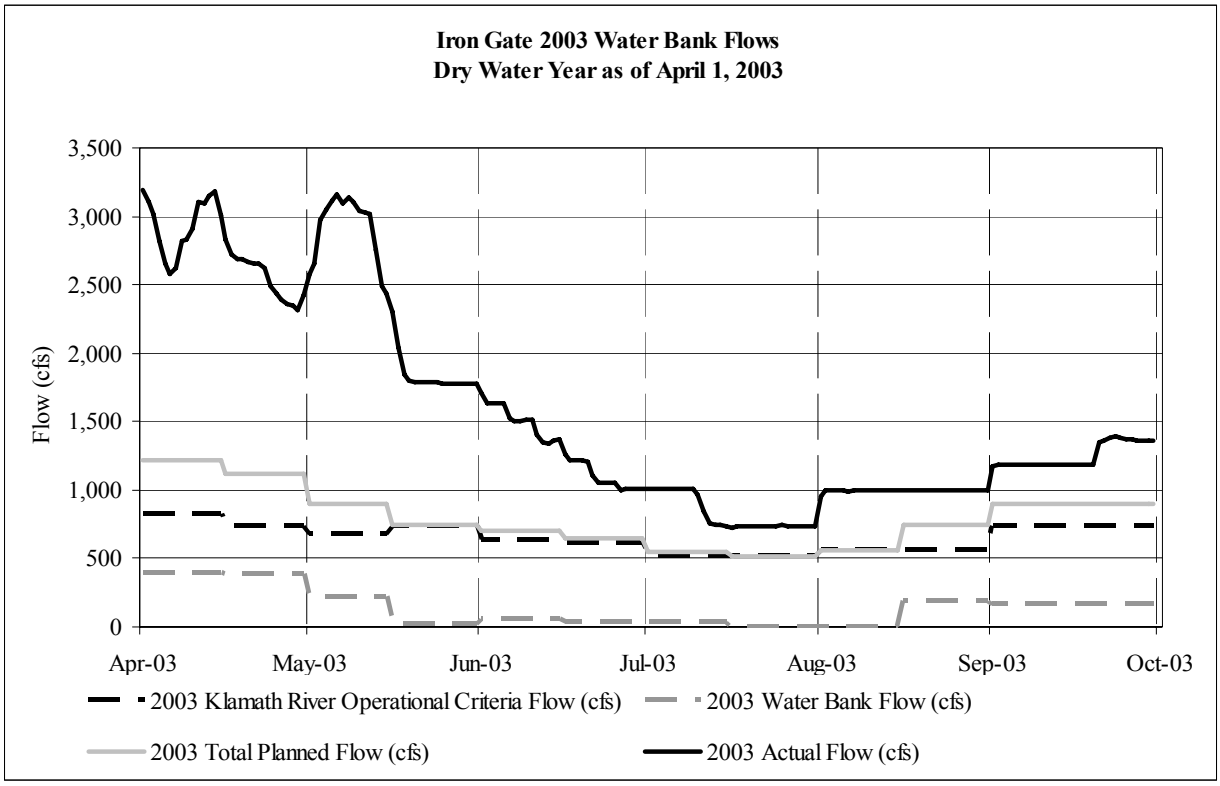


Figure 3-14. Iron Gate flows for April 1 through September 30, 2003. (Source: Reclamation, 2005b; USGS, 2006a, as modified by staff)

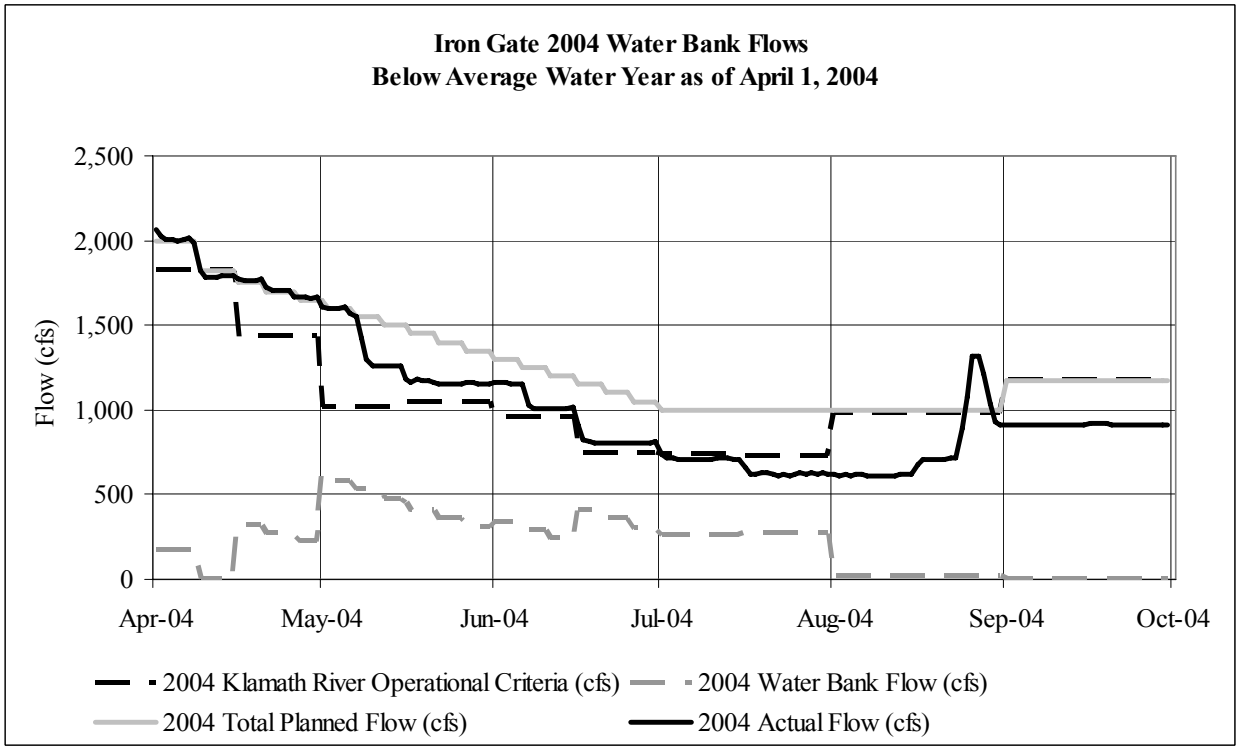


Figure 3-15. Iron Gate flows for April 1 though September 30, 2004. (Source: Reclamation, 2005b; USGS, 2006a, as modified by staff)

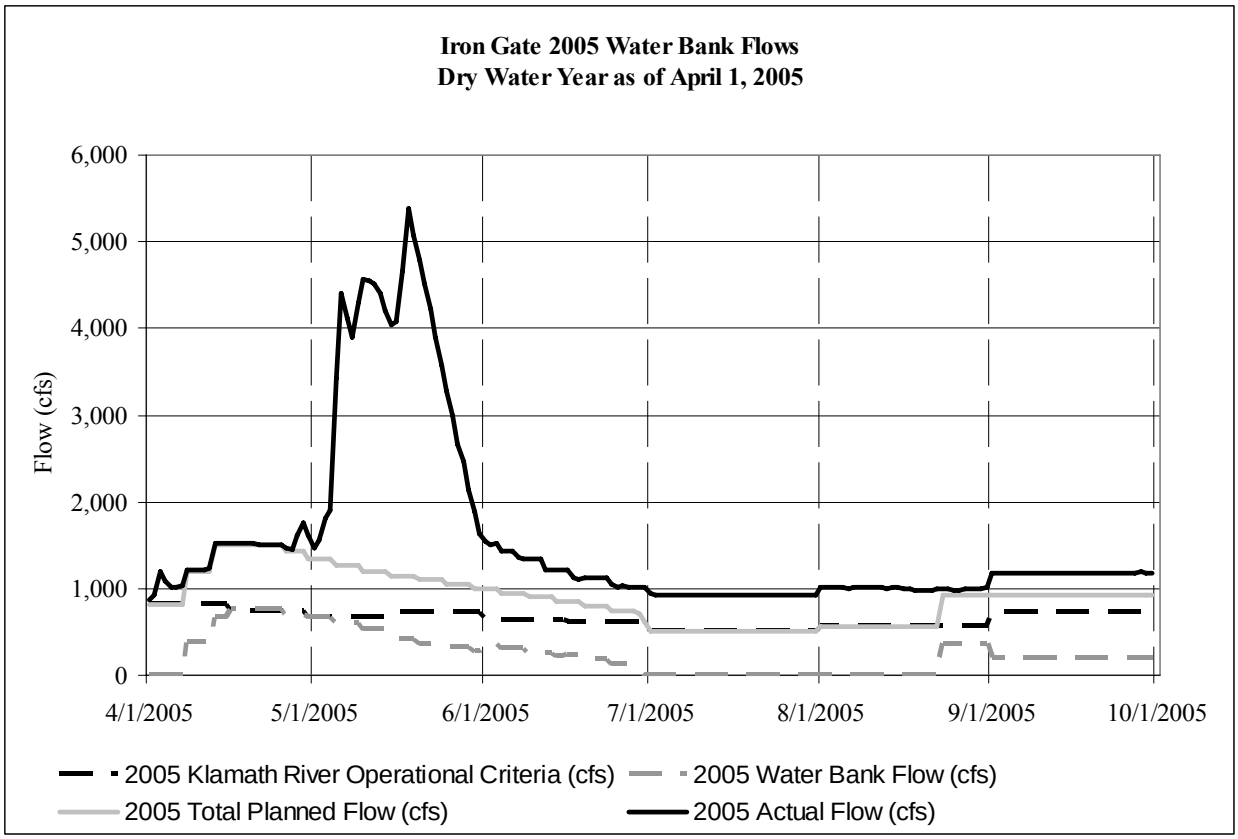


Figure 3-16. Iron Gate flows for April 1 though September 30, 2005. (Source: Reclamation, 2005b; USGS, 2006a, as modified by staff)

Flow releases at Iron Gate dam have recently been revised based on a ruling by the U.S. Ninth Circuit Court of Appeals, settling a lawsuit between the Pacific Coast Federation of Fisherman's Associations, Institute for Fisheries Resources, Northcoast Environmental Center, Klamath Forest Alliance, Oregon Natural Resources Council, the Wilderness Society, Waterwatch of Oregon, Defenders of Wildlife, Headwaters, Representative Mike Thompson, the Yurok Tribe, and the Hoopa Valley Tribe versus Reclamation, NMFS, and the Klamath Water Users Association. This ruling, issued on March 27, 2006, ordered:

- NMFS and Reclamation to reinitiate consultation on the Klamath Irrigation Project;
- NMFS to issue a new BiOp based on the current scientific evidence and the full risks to threatened coho salmon and to provide a copy of the new BiOp to the plaintiffs and to the Court when it is completed;
- Reclamation to limit Klamath Project irrigation deliveries if they would cause water flows in the Klamath River at and below Iron Gate dam to fall below 100 percent of the Phase III flow levels specifically identified by NMFS in the BiOp as necessary to prevent jeopardy, until the new consultation for the Klamath Irrigation Project is completed and reviewed by the U.S. Ninth Court (Earthjustice, 2006).

On March 26, 2007, the U.S. Ninth Court of Appeals rejected an appeal of this court ruling by the Klamath Water Users Association, Tule Lake Irrigation District, William Heiney, and Amos Hoyt.

This ruling has caused implementation of Phase III flows from the NMFS BiOp (table 3-23).

Table 3-23. Phase III, NMFS 2002 BiOp Iron Gate dam releases criteria based on water year. (Source: Reclamation, 2006c).

Water Year Type and Flow (cfs)					
Month	**Wet**	**Above Average**	**Average**	**Below Average**	**Dry**
April	2,050	2,700	2,850	1,575	1,500
May	2,600	3,025	3,025	1,044	1,500
June	2,900	3,000	1,500	1,525	1,400
July	1,000	1,000	1,000	1,000	1,000
August	1,000	1,000	1,000	1,000	1,000
September	1,000	1,000	1,000	1,000	1,000
October	1,300	1,300	1,300	1,300	1,300
November	1,300	1,300	1,300	1,300	1,300
December	1,300	1,300	1,300	1,300	1,300
January	1,300	1,300	1,300	1,300	1,300
February	1,300	1,300	1,300	1,300	1,300
March	2,300	2,525	2,750	1,725	1,450

Downstream of Iron Gate Dam

Downstream of Iron Gate dam, the Klamath River flows freely for 190 miles to its estuary and the Pacific Ocean. Four major tributaries enter this reach: the Shasta, Scott, Salmon, and Trinity rivers. These four tributaries contribute about 44 percent of the Klamath River Basin's mean annual runoff and have a substantial influence on the timing of peak and low flow rates within the Lower Klamath River. Table 3-24 summarizes drainage areas and mean monthly and annual flows for these four main tributaries and for three USGS gages along the Lower Klamath River.

Shasta River

The Shasta River enters the Klamath River at RM 176.6, 13.5 miles downstream from Iron Gate dam. The Shasta River watershed includes the glaciated slopes of Mt Shasta, but is largely rangeland with substantial amounts of irrigated pastureland and agricultural area. The average precipitation in the watershed varies greatly with exposure and elevation, but is about 15 inches per year due to the rain shadow effects of the mountains to the west of the watershed. The hydrograph for the Shasta River near the confluence with the Klamath River shows a peak in the winter and minimum median flows under 40 cfs during July and August (see table 3-24). The current hydrology of the Shasta River is affected by surface-water diversions, alluvial pumping, and the Dwinnell dam which creates Lake Shastina (see figure 1-1). Historically, springs and seeps dominated the hydrograph of the Shasta River resulting in a cool and stable river flow (NAS, 2004). Dwinnell dam, about 25 miles upstream from the Klamath River at a location that controls 15 percent of the total drainage area of the Shasta River, was constructed in 1928 and has a normal storage capacity of 50,000 acre-feet. The majority of the water in Lake Shastina is retained during the winter and early spring and then used for irrigation during the later spring and summer. Other than during above average and wet water years, the only release from Lake Shastina is flow needed to meet downstream water user requirements. Farther downstream, there are seven major diversion dams and numerous smaller dams or weirs on the Shasta River and its tributaries. When these diversions are in operation during the irrigation season, they substantially and rapidly reduce flows in the mainstem causing complete dewatering of the main channel in some reaches of the river during the late summer of dry years (NAS, 2004).

Table 3-24. Monthly discharge (cfs) statistics for USGS gages along the Lower Klamath River and for the Shasta, Scott, Salmon, and Trinity rivers. (Source: USGS, 2006a, as modified by staff)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Shasta River near Yreka, CA, USGS gage no. 11517500 (water years 1963 through 2004). Gage data prorated by 1.0485 to the confluence with the Klamath. Shasta River drainage area, 800 square miles													
Mean	161	215	303	388	345	342	212	156	110	52	41	75	199
Median	157	195	219	250	278	268	167	121	82	39	33	68	166
Max.	1,311	910	10,904	8,828	2,558	2,726	2,768	1,143	969	285	245	475	10,904
Min.	34	129	138	146	148	48	18	13	6	2	2	5	2
10% Exceed.	212	279	435	658	577	569	399	295	203	105	74	129	373
90% Exceed.	105	160	167	178	182	151	56	49	26	16	14	25	27
Scott River at Fort Jones, CA, USGS gage no. 11519500 (water years 1963 through 2004). Gage data prorated by 1.2557 to the confluence of the Klamath River. Scott River drainage area, 820 square miles.													
Mean	120	426	1,041	1,426	1,394	1,425	1,255	1,394	850	213	65	59	803
Median	80	148	420	707	1,008	1,069	1,186	1,175	618	124	53	55	377
Max.	8,514	8,062	49,602	38,802	16,953	16,325	8,213	6,065	5,776	1,695	701	556	49,602
Min.	5	6	16	68	100	80	63	88	12	9	5	4	4
10% Exceed.	158	1,052	2,422	2,838	2,763	2,648	2,160	2,598	1,884	534	119	95	1,946
90% Exceed.	21	63	117	159	300	466	428	454	157	36	10	12	26
Klamath River at Seiad Valley, CA, USGS gage no. 11520500 (water years 1963 to 2004). Drainage area, 6,940 square miles, does not include Lost River.													
Mean	1,990	2,978	4,805	6,102	5,976	6,637	5,582	4,720	2,754	1,313	1,186	1,484	3,784
Median	1,735	2,280	3,320	4,120	4,790	5,120	5,045	4,015	2,180	1,120	1,230	1,540	2,370
Max.	14,900	15,000	115,000	108,000	42,400	51,900	31,600	14,100	12,900	7,200	2,650	2,710	115,000
Min.	963	1,080	1,180	1,210	1,070	1,020	1,070	954	603	552	398	464	398
10% Exceed.	3,219	5,231	8,293	12,000	11,100	13,000	9,873	8,620	4,923	2,010	1,470	2,010	8,100
90% Exceed.	1,171	1,399	1,761	1,910	1,816	2,013	2,140	1,831	1,160	838	799	914	1,050
Salmon River at Somes Bar, CA, USGS gage no. 11522500 (water years 1963 to 2004). Drainage area of the gage and the Salmon River, 751 square miles.													
Mean	340	1,209	2,492	3,375	3,034	3,148	2,859	2,952	1,796	612	273	214	1,853
Median	207	436	1,310	1,970	2,240	2,360	2,660	2,630	1,400	481	251	196	1,050
Max.	12,300	22,000	100,000	64,400	31,200	43,600	15,200	11,000	8,800	4,160	3,950	1,990	100,000
Min.	83	119	179	182	182	281	399	570	224	107	72	60	60
10% Exceed.	504	3,021	5,887	6,500	5,534	5,440	4,690	5,150	3,602	1,170	417	285	4,210
90% Exceed.	122	200	362	550	843	1,120	1,269	1,130	560	233	138	121	173

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Klamath River at Orleans, CA, USGS gage no. 11523000 (water years 1963 through 2004). Drainage area, 8,475 square miles does not include Lost River.													
Mean	2,814	6,353	12,023	16,011	15,153	15,252	12,731	10,936	6,166	2,566	1,835	1,994	8,624
Median	2,320	3,690	7,075	9,460	11,500	12,100	11,700	9,335	4,820	2,210	1,840	2,010	4,840
Max.	33,400	83,900	240,000	240,000	229,000	151,000	72,900	34,000	28,500	12,200	7,970	7,630	240,000
Min.	1,110	1,510	1,880	2,150	2,150	2,240	2,330	1,930	1,380	824	652	652	652
10% Exceed.	4,218	14,810	25,190	31,200	27,200	27,290	21,800	19,100	11,810	4,220	2,400	2,520	19,200
90% Exceed.	1,501	2,180	2,931	3,651	4,516	5,264	5,050	4,002	2,369	1,420	1,220	1,260	1,590
Trinity River at Hoopa, CA, USGS gage no. 11530000 (water years 1912 to 1962, not including 1916 through 1931). Gage data prorated by 1.01647 to the confluence with the Klamath River. Trinity River drainage area, 2,900 square miles. Pre-Trinity River Diversion.													
Mean	919	2,563	6,475	8,999	11,927	10,456	10,102	8,510	4,682	1,620	661	515	5,584
Median	547	1,138	2,785	5,164	7,644	8,762	9,026	8,254	3,929	1,311	575	456	2,963
Max.	53,162	53,975	160,603	95,447	115,878	70,137	38,423	28,766	14,942	6,993	2,216	3,822	160,603
Min.	165	299	386	413	933	2,704	3,700	1,952	671	318	213	191	165
10% Exceed.	1,248	6,330	15,979	22,464	26,449	17,809	16,569	13,824	9,405	2,978	1,098	765	12,706
90% Exceed.	323	468	791	1,250	2,846	4,692	4,878	3,468	1,769	666	343	300	455
Trinity River at Hoopa, CA, USGS gage no. 11530000 (water years 1963 through 2004). Gage data prorated by 1.01647 to the confluence with the Klamath River. Trinity River drainage area, 2,900 square miles. Post Trinity River Diversion.													
Mean	905	2,983	7,230	10,859	10,321	9,993	6,967	5,004	2,882	1,285	775	691	4,969
Median	701	1,149	3,466	6,231	7,090	6,993	5,453	4,035	2,185	1,098	699	623	2,236
Max.	23,074	36,491	170,768	119,944	99,919	86,604	45,843	20,126	15,755	5,855	6,170	3,802	170,768
Min.	311	498	511	555	630	1,047	986	1,027	422	275	248	292	248
10% Exceed.	1,169	7,959	16,975	25,910	22,820	20,319	12,513	9,544	5,207	2,062	1,138	984	11,588
90% Exceed.	490	689	961	1,474	2,719	3,020	2,550	2,043	1,189	691	469	447	607
Klamath River near Klamath, CA, USGS gage no. 11530500 (water years 1963 to 2004).[a] Drainage area, 12,100 square miles, does not include Lost River													
Mean	4,720	13,811	25,967	34,535	33,348	33,525	25,718	19,445	11,156	4,667	3,125	3,219	17,667
Median	3,760	6,550	14,900	21,650	24,650	25,200	21,100	16,200	8,790	3,990	2,960	3,000	9,580
Max.	79,000	140,000	420,000	397,000	404,000	317,000	173,000	55,600	63,100	25,100	20,900	14,200	420,000
Min.	1,910	2,320	3,070	3,480	3,300	5,030	4,410	4,680	2,100	1,440	1,340	1,310	1,310
10% Exceed.	6,508	35,600	58,320	74,840	67,610	62,820	44,110	35,410	20,000	7,558	4,350	4,210	40,100
90% Exceed.	2,588	3,580	5,280	7,250	9,999	12,800	10,290	8,347	4,530	2,649	2,030	2,020	2,700

[a] For water years 1963 to 2004; data for December 31, 1994 to January 6, 1995 and October 30, 1995 to September 30, 1997 are missing.

Scott River

The Scott River enters the Klamath River at RM 143, 47.1 miles downstream from Iron Gate dam. The Scott River watershed includes the heavily forested and relatively wet Salmon Mountains on its western divide, but these mountains create a rain shadow for the rest of the watershed. Similar to the Shasta River valley, many areas in the Scott River valley have been extensively altered for grazing and agriculture. Although the Scott River watershed is almost the same size as the Shasta River watershed, the hydrograph for the Scott River near the confluence with the Klamath River has 4 to 5 times higher median monthly flows in the winter and spring months (see table 3-24). Somewhat similar to the Shasta River, the minimum monthly median flows near 50 cfs occur during August and September.

Klamath River at Seiad Valley

USGS gage no. 11520500, Klamath River at Seiad Valley at RM 128.5, is below the confluences with the Shasta and Scott rivers. Releases from Iron Gate dam represent more than 75 percent of the flow during the low flow months of August, September, October, and November, but less than 50 percent during the higher flow months of April, May, and June at this location. Figure 3-17 shows daily flow at the Klamath River at Seiad Valley from water years 1963 to 2004, the same period shown in table 3-24.

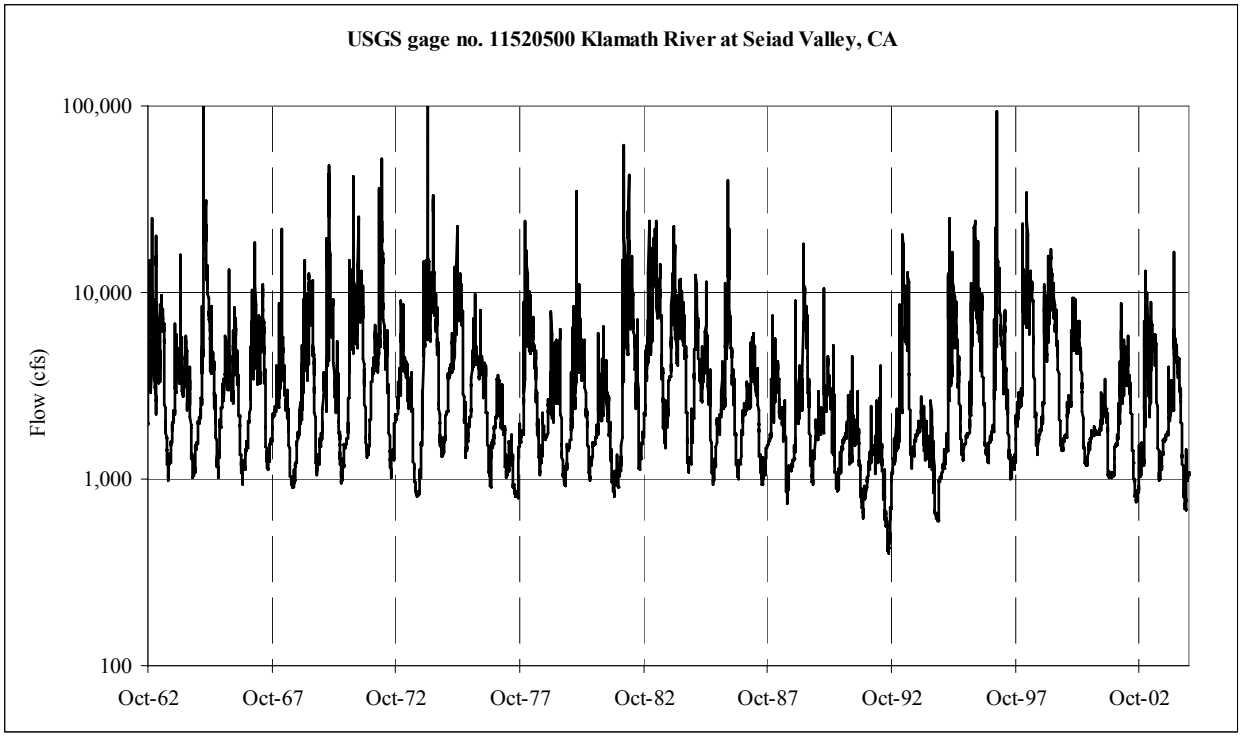


Figure 3-17. Daily Klamath River flow at Seiad Valley (USGS gage no. 11520500) for water years 1963 to 2004. (Source: USGS, 2006a, as modified by staff)

Salmon River

The Salmon River enters the Klamath River at RM 66, 124.1 miles downstream from Iron Gate dam. The Salmon River watershed is generally steep, forested, and largely federally owned within the Klamath National Forest and several designated wilderness areas. The area is largely undisturbed except for logging, fires, and mining activity. As table 3-24 indicates, the Salmon River hydrograph at the confluence with the Klamath River shows high average flows (3,375 cfs) during January, representing rain or rain on snow events that are normally the peak flooding events during the winter, and a more

sustained and consistent spring high flow period in April and May (median flow, 2,660 and 2,630 cfs, respectively) representing snowmelt from the higher terrain where a deep snowpack accumulates. The minimum monthly median flow of about 200 cfs occurs during September.

Klamath River at Orleans

USGS gage no. 11523000, Klamath River at Orleans at RM 60, is below the confluences with the Shasta, Scott, and Salmon rivers as well as other smaller tributaries. As the Klamath River flows generally westward, it enters an area of higher precipitation as compared to the Shasta, Scott, and the Klamath River above Iron Gate dam, resulting in much higher flows during the winter and spring months as compared to upstream areas. However, releases from Iron Gate dam still represent more than 50 percent of the flow during the low flow months of August, September, and October, but 20 percent or less during the higher flow months of April, May, and June at this location. Figure 3-18 shows daily flow here from water years 1963 to 2004, the same period of record summarized for this gage in table 3-24.

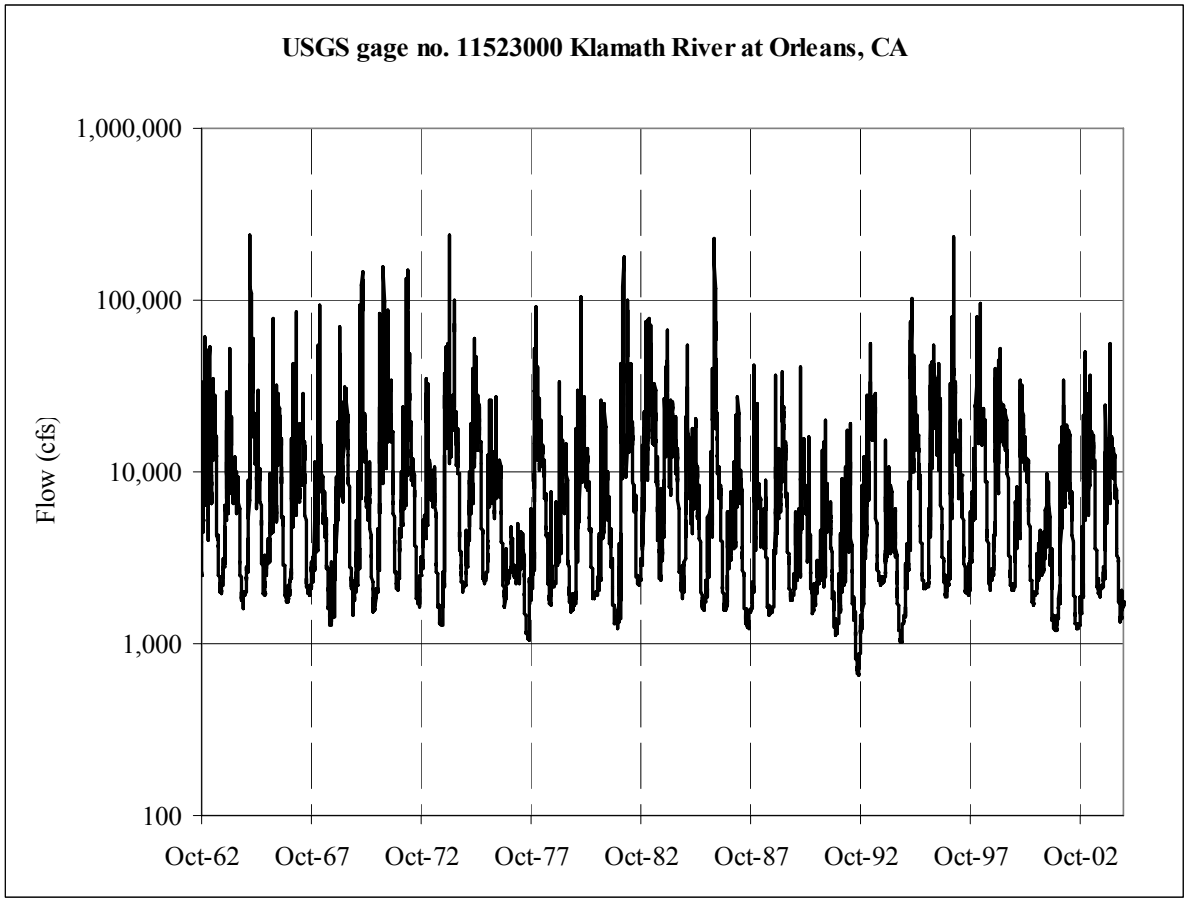


Figure 3-18. Daily Klamath River flow at Orleans (USGS gage no. 11523000) for water years 1963 to 2004. (Source: USGS, 2006a, as modified by staff)

Trinity River

The Trinity River enters the Klamath River at RM 40, 150 miles downstream of Iron Gate dam. The Trinity River is the largest tributary to the Klamath River. The Trinity watershed is generally wet, steep, forested, and largely federally owned within several national forests and wilderness areas. As table 3-24 shows, the Trinity River hydrograph at the confluence with the Klamath River has peak median monthly flows in February and March near 7,000 cfs, gradually declining to about 600 cfs in September.

A main feature of the Trinity River watershed is Trinity Lake. This reservoir has a storage capacity of 2.4 million acre-feet and is located 119 miles upstream from the Klamath River along the main branch of the Trinity River (see figure 1-1). Both Trinity Lake and the much smaller downstream Lewiston reservoir were constructed in the early 1960s as part of the Central Valley Project's Trinity River Division. For the first 10 years of full operation, these reservoirs and the TRD, an average of nearly 90 percent or 1.2 million acre-feet of the annual river flow at the Lewiston reservoir (drainage area of 692 square miles) was been diverted via the Clear Creek Tunnel to Whiskeytown Lake and then to the Sacramento River system (Interior, 2000). CDWR estimates that about 1.1 million acre-feet per year were diverted during 1964 to 1986 and 0.73 million acre-feet during 1987 to 2000. Figure 3-19 illustrates the influence that diversion of flow has on the flow duration curves for the Trinity River at its confluence with the Klamath River. Data for pre- and post-TRD operation in table 3-24 shows the influence of these diversions on monthly Trinity River flows at the Klamath River confluence, which is most pronounced (lower) during April through July. Figure 3-20 shows the daily flow from the Trinity River at the confluence with the Klamath River for water years 1963 to 2004.

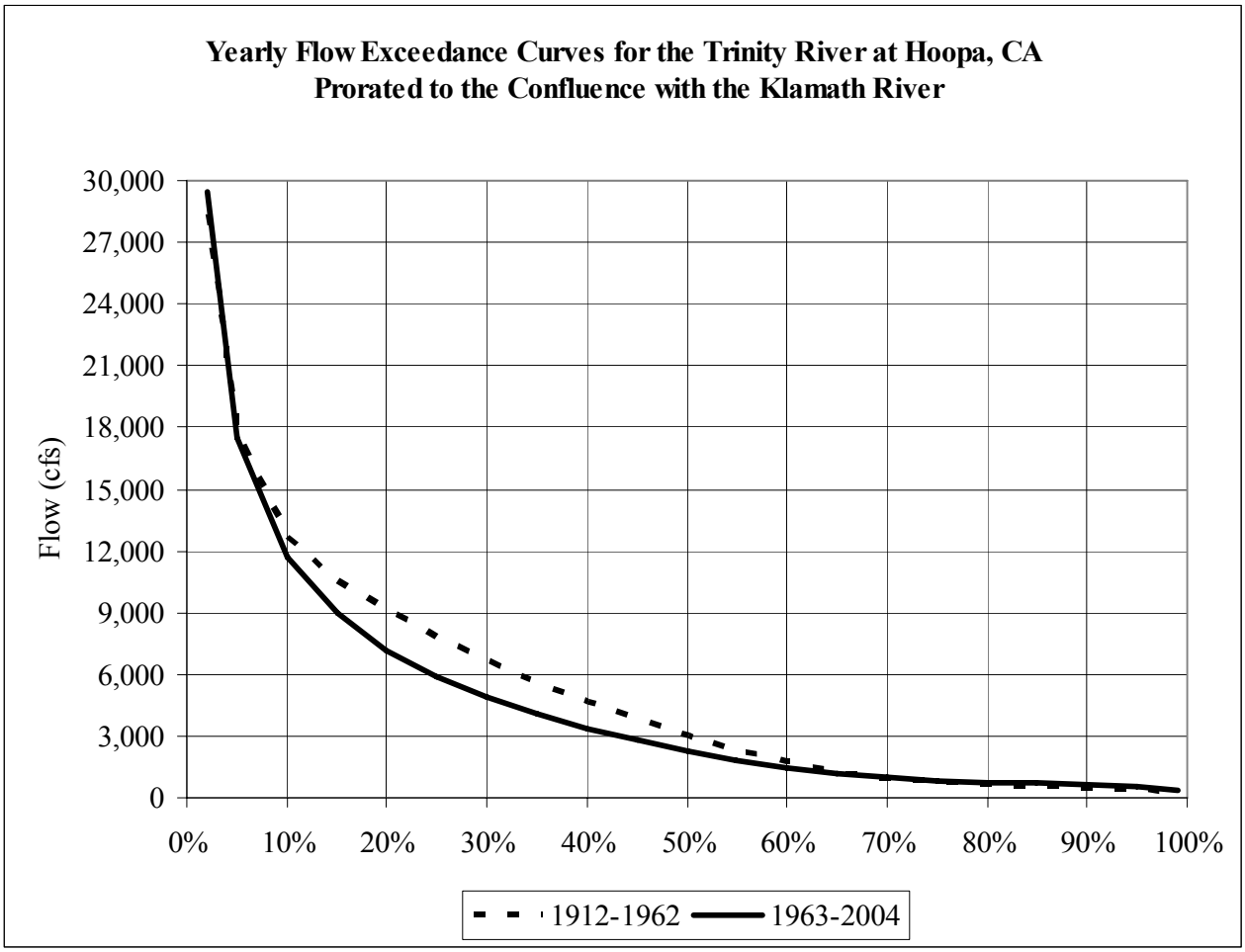
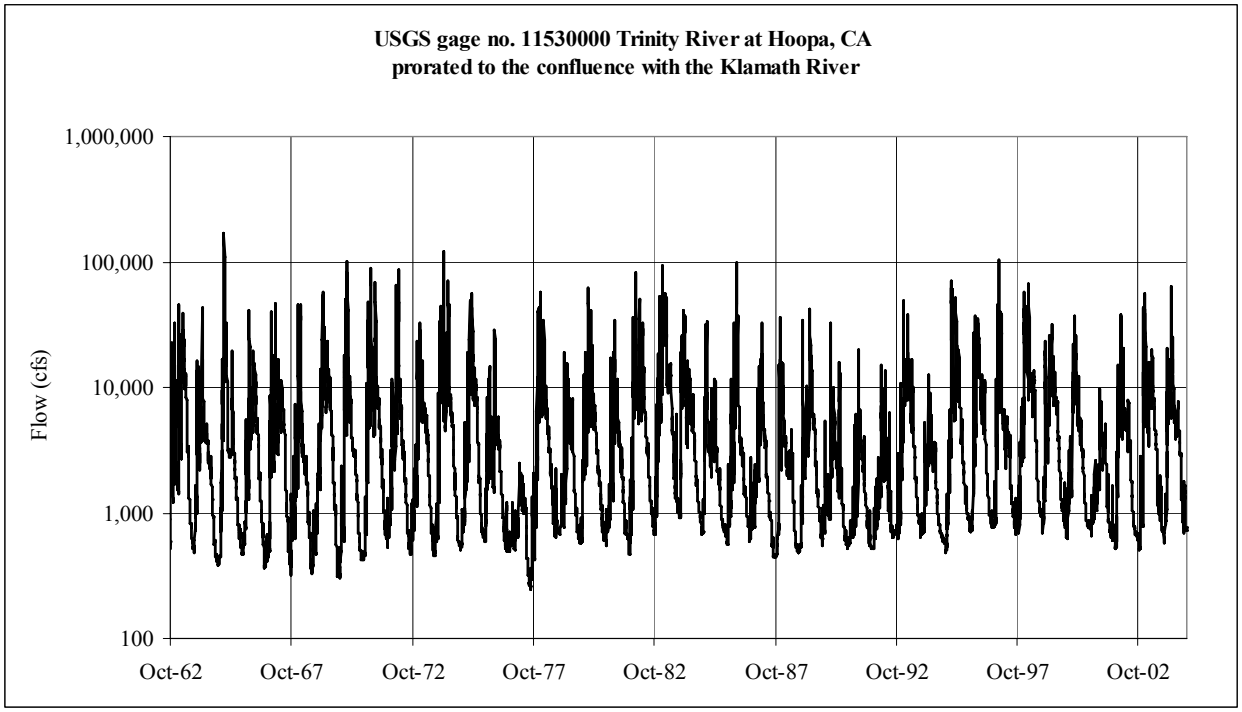


Figure 3-19. Yearly flow exceedance curves for gage no. 11530000 Trinity River at Hoopa, CA, representing pre- and post-TRD flow conditions. (Source: USGS, 2006a, as modified by staff)



Note: Prorated by a factor of 1.01647 to the confluence with the Klamath River.

Figure 3-20. Daily inflow from the Trinity River at the confluence with the Klamath River for water years 1963 to 2004. (Source: USGS, 2006a, as modified by staff)

The TRD has a substantial history of review and revisions to its flow regime. In 1973, the Cal Fish & Game requested that Reclamation release an annual volume of 315,000 acre-feet to reverse the steelhead and Chinook salmon declines. However, a combination of flood and drought resulted in a release of 705,000 acre-feet in 1974, 275,000 acre-feet in 1975, and 126,000 acre-feet in 1976 and Cal Fish & Game was not able to complete a formal evaluation of the effect of the flows (FWS and Hoopa Valley Tribe, 1999). In 1980, Interior prepared an EIS concerning a proposal to increase stream flows in the Trinity to restore steelhead and salmon populations. Based on this EIS, Interior issued a decision on January 14, 1981, to conduct the Trinity River Flow Evaluation to evaluate the effects on fish habitat by increasing annual releases to 340,000 acre-feet in normal and wet years, 220,000 acre-feet in dry years, and 140,000 acre-feet in critically dry years. In 1984, the Trinity River Basin Fish and Wildlife Management Act was signed by Congress, authorizing Interior to develop and implement a management program to restore the fish and wildlife populations in the Trinity River Basin to levels that existed prior to construction of the Trinity and Lewiston dams. The goals of the initial program (FWS and Hoopa Valley Tribe, 1999) included:

- Improve the capability of the Trinity River Hatchery to mitigate for salmon and steelhead fishery losses that have occurred above Lewiston dam.
- Restore natural (instream spawning) salmon and steelhead production in the mainstem and tributaries below Lewiston dam to pre-dam levels.
- Contribute to fish harvest management.
- Compensate for deer and other wildlife losses from flooding of habitat and reduced streamflow resulting from diversions to the Central Valley Project.

- Develop and implement land management activities to stabilize watersheds and reduce sediment yield to Trinity River tributaries.

The Central Valley Project Improvement Act of 1992 further supported restoration objectives and acknowledged the federal government's trust responsibilities by specifying minimum releases of 340,000 acre-feet per year pending completion of a flow evaluation study.

The current flow release program from Lewiston dam to the Trinity River is based on the Trinity River Mainstem Fishery Restoration EIS, completed in October 2000. In December 2000, Interior issued the Record of Decision (Trinity ROD) for the Trinity River Mainstem Fishery Restoration, but these flows did not go into full effect until November 2004. Shortly after the ROD was signed, a group of Central Valley Project water and power users filed suit to prevent its implementation. On March 19, 2001, the Eastern District Court decided that part of the decision that provided increased flows for the Trinity River, required preparation of a Supplemental EIS, and allowed other aspects of the program to proceed. Appeals were heard by the U.S. Ninth Circuit Court of Appeals, and a final ruling was issued on November 5, 2004, in favor of the defendants that directs all aspects of the program to proceed and overturned the lower court's requirement to complete the Supplemental EIS. The plaintiffs have indicated they will not appeal to the Supreme Court.

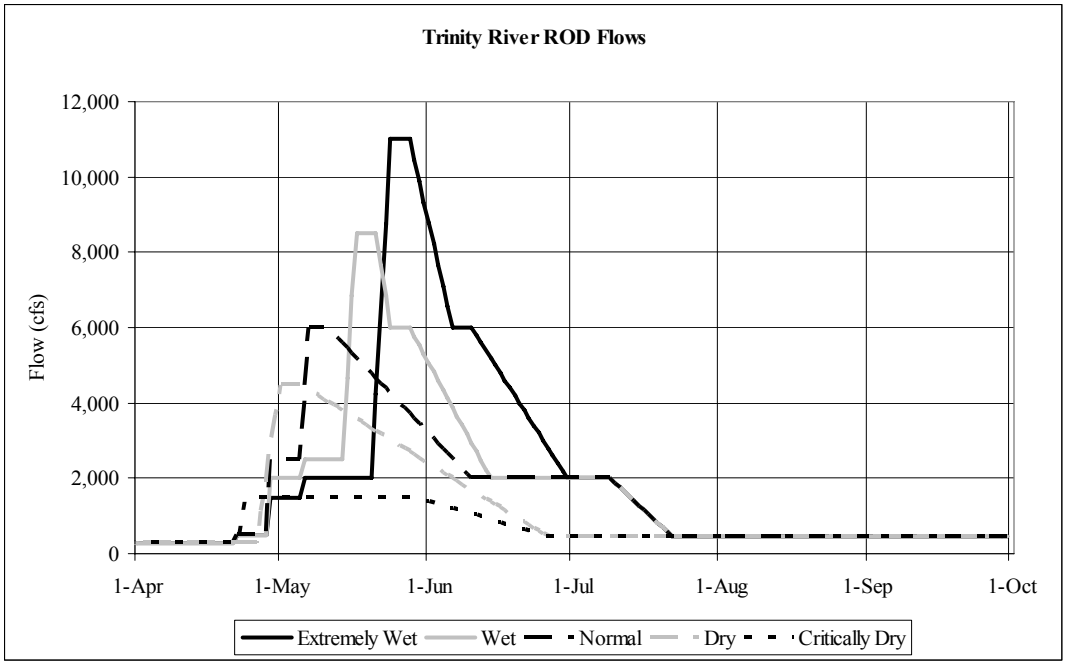
Included in the Trinity ROD, which was based partly on the Trinity River Flow Evaluation (FWS and Hoopa Valley Tribe, 1999) and other studies, was a requirement for releases from Lewiston reservoir during the spring and early summer based on the water year type. Interior states that these flows are necessary to restore and maintain the Trinity River fishery resources by:

- providing physical fish habitat (i.e., appropriate depths and velocities) and suitable temperature regimes for anadromous salmonids; and
- restoring the riverine processes that create and maintain the structural integrity and spatial complexity of the fish habitats.

In addition, the Trinity ROD provides guidelines for mechanical channel rehabilitation, sediment management, watershed restoration, infrastructure improvement, adaptive environmental assessment and management programs, and measures to minimize and mitigate effects (Interior, 2000). The Trinity ROD flow release schedule is based on five different water year types, as they are determined on April 1 each year and the total yearly releases are approximately 48 percent of the natural (pre-TRD) flow at Lewiston dam. Figure 3-21 shows the details of these releases.

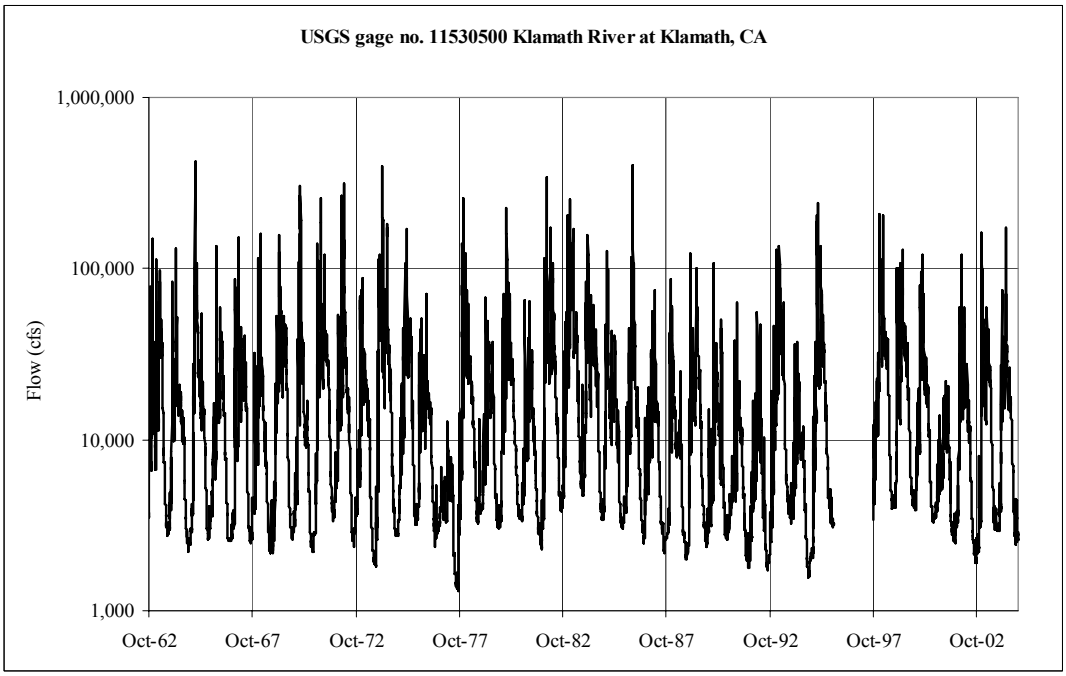
Klamath River at Klamath

Flows near the mouth of the Klamath River (RM 5) are measured by USGS gage no. 11530500 (see table 3-24). This gage is sometimes affected by tidal influences during low flow periods. Releases from Iron Gate dam still account for nearly 40 percent median flows of the low flow months of September and October, close to the drainage area ratio of 38 percent between Iron Gate dam and this location. During other months, especially during the winter and spring, over 85 percent of the hydrograph at this location is from sources other than releases from Iron Gate dam. Figure 3-22 shows daily flow from water years 1963 to 2004.



Note: Summer baseflow (late August to October 15) is 450 cfs; winter baseflow (October 16 to late April) is 300 cfs. Total volumes (thousand acre-feet): extremely wet 815, wet 701, normal 647, dry 453, and critically dry 369.

Figure 3-21. Flow release schedule from Lewiston reservoir based on the 2000 Record of Decision. (Source: Interior, 2000; FWS and Hoopa Valley Tribe, 1999)



Note: Data for this gage during the 1963–2004 water year period do not include daily flow data for December 31, 1994 to January 6, 1995 and October 30, 1995 to September 30, 1997.

Figure 3-22. Daily flow at USGS gage no. 11530500 Klamath River at Klamath, CA for water years 1963 to 2004. (Source: USGS, 2006a, as modified by staff)

3.3.2.1.2 Water Quality

The Klamath River watershed extends from southeastern Oregon to the coast of northern California. Water quality standards (referred to as objectives in California) are set by the Oregon Department of Environmental Quality (Oregon Environmental Quality) and NCRWQCB and published in the Oregon Administrative Rules (OAR) (Oregon Environmental Quality, 2003) and RWQCB Basin Plan (Basin Plan), respectively. According to Oregon Environmental Quality (2003), the existing beneficial uses within the Klamath River to the California border include: municipal and domestic supply, irrigation, stock watering, fish and aquatic life,[54] wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, hydropower, and commercial navigation and transportation.

According to the Basin Plan, which lists beneficial uses by hydrological area,[55] the existing and potential beneficial uses within the middle and lower Klamath River from the Oregon border to the Pacific Ocean include: municipal and domestic supply, agricultural supply, industrial service and process supply, groundwater recharge (excluding the Copco and Iron Gate hydrological subareas), freshwater replenishment, navigation, hydropower generation, contact and non-contact water recreation, commercial and sport fishing, aquaculture, warm and cold freshwater habitat, estuarine habitat (Lower Klamath River hydrological area only), wildlife habitat, rare, threatened or endangered species, migration of aquatic organisms, spawning, reproduction, and/or early development of fish, and Native American culture (various locations in both the middle and lower Klamath hydrological areas), marine habitat (lower Klamath River hydrological area in the Klamath Glen hydrological subarea), and shellfish harvesting in the middle Klamath hydrological area in the Iron Gate hydrological subarea, and in the lower Klamath hydrological area (it is a potential use in the Orleans hydrological subarea: Basin Plan, 2007).

Table 3-25 shows state water quality criteria and objectives. In addition, Cal Fish & Game's management plan for the 6-mile portion of the peaking reach from the Oregon border to Copco reservoir has water quality goals consistent with its designation as a Wild Trout Area (discussed further in section 3.3.3, *Aquatic Resources*). Temperatures in this reach are not to exceed 21.1°C on an instantaneous basis and not to exceed 15.6°C for longer than 12 hours (Rogers et al., 2000).

The Oregon 2002 303(d) list (the most recent approved by EPA) reported that various reaches of the Klamath River from upper Klamath Lake to the California state line were impaired because of pH, ammonia, nutrients, temperatures, dissolved oxygen (DO), and chlorophyll *a* that do not meet applicable standards (Oregon Environmental Quality, 2002a). Oregon Environmental Quality submitted its 2004/2006 section 303(d) list of water quality limited waters needing a TMDL to EPA for approval on May 23, 2006. In this more recent EPA submittal, Oregon Environmental Quality identifies the reach from Keno dam to the California state line as limited for temperature and DO, and the reach encompassing Keno reservoir as limited for ammonia, chlorophyll *a*, and pH (Oregon Environmental Quality, 2006).

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[54]Cool water species (no salmonid use) in the Klamath River from Upper Klamath Lake to Keno dam and rainbow trout from Keno dam to the California border.

[55]The Basin Plan divides the Klamath River into two hydrological areas, the middle and lower Klamath River. The middle Klamath River is divided into seven hydrologic subareas which cover the Klamath River from the Oregon border to the confluence with the Salmon River. Copco hydrological subarea begins at the Oregon border and terminates directly above Iron Gate reservoir where the Iron Gate subarea begins. The Iron Gate hydrological subarea ends about 2 miles below the dam above the confluence with Willow Creek. The Lower Klamath River hydrological area begins at the confluence with the Salmon River and extends to the Pacific Ocean.

Table 3-25. Applicable water quality criteria and objectives for Klamath Basin in the vicinity of the Klamath Hydroelectric Project. (Source: Oregon Environmental Quality, 2003; Basin Plan, 2007)

Constituent	Oregon Criteria	California Objectives
Temperature[a]	7-day average maximum (max) not to exceed 20ºC in waters designated for rainbow trout. 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.[b] If the natural thermal potential of a water body exceeds 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.
Dissolved Oxygen	At Oregon Environmental Quality's 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 Oregon Environmental Quality's 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. Spawning criteria applied between January 1 to May 15, 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 and 50% or more of the monthly means in a calendar year must be above 10.0 mg/L from the state line to the Pacific Ocean on the Klamath River. The portions of Jenny and Fall creeks in California (and all other streams in the Middle Klamath hydrologic area) must be above the minimum of 7.0 mg/L and 50% or more of the monthly means must be above 9 mg/L.
Nuisance phytoplankton growth (Oregon) and nutrients (California)	If chlorophyll *a* exceeds an action level of 0.015 mg/L,[c] Oregon Environmental Quality 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.
pH	Values shall not fall outside the range of 6.5-9.0.[d]	Values shall not fall outside the range of 7.0-8.5.
Toxic Substances (including ammonia)	Shall not exceed criteria listed in OAR 340-041-0033, Table 20. Ammonia, as recommended by the EPA: At 20°C, the long term criteria (30 day average) when fish early life stages are present, (pH between 9.0 and 6.5) range from 0.34 mg/L to 4.68 mg/L. Acute criteria (pH between 9.0 and 6.5) range from 0.885 mg/L to 32.6 mg/L when salmonids present.	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. The Basin Plan uses the EPA recommended criteria for ammonia listed in the adjacent column.
Turbidity (NTU)	Except for certain limited duration activities, no more than a 10 percent increase above natural background levels, as measured relative to a control point immediately upstream of the turbidity causing activity.	No more than 20 percent increase above natural background levels (except as otherwise allowed by permit or waiver).

Constituent	Oregon Criteria	California Objectives
Sediment		Suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered to cause nuisance or adversely affect beneficial uses.
Total Dissolved Gas	Shall not exceed 110 percent saturation[e] Shall not exceed 105 percent saturation in water < 2-feet deep.	
Specific Conductance	Unless otherwise authorized by Oregon Environmental Quality, specific conductance shall not exceed a guideline value of 400 micromhos (measured at 77ºF) at the Oregon-California border (RM 208.5).	At 77ºF, 90% or more of the monthly mean values must be less than or equal to 425 micromhos and 50% of the values must be less than 275 micromhos above Iron Gate dam. Below Iron Gate dam 90% of the monthly mean values must be below 350 micromhos and 50% of the monthly mean values must be below 275 micromhos.
Taste and Odor	Creation of tastes or odors deleterious to aquatic life, potability of drinking water, or palatability of fish or shellfish may not be allowed.	Shall not contain taste or odor producing substances that impart undesirable taste or 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.	

[a] NCRWQCB has proposed amendments to the Basin Plan that would revise the instream water quality objectives for temperature and DO to fully protect salmonids by providing specific biologically based objectives for each salmonid life stage.

[b] 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. Project related waters designated by Oregon Environmental Quality for rainbow trout include the Klamath River from Keno dam to the California state line including the J.C. Boyle bypassed and peaking reaches, and the Oregon portions of Fall, Jenny, and Spring creeks.

[c] Calculated from a minimum of three samples collected in any 3 consecutive months at a minimum of 1 representative location (e.g., mid river or deepest part of lake) from samples integrated from the surface to a depth twice the Secchi depth or the bottom, which ever is lesser of the two. The regulations also state that the standards could be met under any other methods approved by Oregon Environmental Quality.

[d] 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.

[e] Exceedances of TDG criteria are not violations if they occur when stream flow exceeds 10-year, 7-day average flood.

The California 2002 303(d) list reported that the entire length of the Klamath River was impaired from the state line to the river's confluence with the Pacific Ocean because of nutrients, organic enrichment, DO, and temperatures that do not meet applicable numerical or narrative water quality objectives (Water Board, 2002). In addition, NCRWQCB states that Klamath River waters within the project boundaries currently do not meet the applicable objectives for pH, ammonia toxicity, taste and odor, floating material, settleable material, and chemical constituents. In its December 1, 2006, letter to the Commission, NCRWQCB reports that beneficial uses that are impaired in the project area include: cold freshwater habitat; rare, threatened, or endangered species; migration of aquatic organisms; spawning, reproduction, and/or early development; commercial and sport fishing; Native American culture; contact and non-contact water recreation; municipal and domestic supply; wildlife habitat; navigation; and agricultural and industrial service supply.

Water quality in the project area (i.e., downstream of Link River dam) is strongly influenced by the quality of water entering the Klamath River from not only Upper Klamath Lake, but also Lost River and Klamath Straits drain, in addition to its residence time within project impoundments. During wet months, sources other than the Link River provide about one-third of the total flow reaching Iron Gate dam; in midsummer, these sources may account for up to half of the total water reaching Iron Gate dam. As such, source water of diverse quality influences the quality of the water within the project-affected reaches (NAS, 2004).

Temperature

Oregon and California listed the Klamath River from Upper Klamath Lake to the Pacific Ocean, the Lost River, and Klamath Straits drain in 2002 on their respective 303(d) lists as temperature impaired. Monthly sampling results from March through November compiled by PacifiCorp indicate that water temperatures below Keno reservoir are typically below 10°C in March (table 3-26), while continuous sampling results show summer temperatures (June, July, August, and September) over 20°C were observed along the Klamath River at almost all sampling sites below Iron Gate dam during at least July and August (figures 3-23 through 3-25). Water temperatures in Upper Klamath Lake and Link River are routinely at or above 20°C from June through September. Water temperatures increase slightly in Keno reservoir due in part to the relatively shallow nature of the reservoir which enhances solar warming and warm agriculturally influenced water inputs from the Lost River and Klamath Straits drain. Average water temperatures below Keno dam were slightly cooler as the reach becomes steep, free flowing, and receives groundwater inputs.

In addition to the collection and compilation of longitudinal water temperature data for river reaches, PacifiCorp also conducted vertical water temperature profile monitoring near the dams in the major project reservoirs from 2000 through 2003. The results show that the shallow, upstream reservoirs (Keno and J.C. Boyle) do not exhibit long term, stable thermal stratification in the summer, and the difference between surface water temperatures and the bottom is typically less than 2°C.

Temperatures in the J.C. Boyle bypassed reach are modified by the contribution of about 250 to 300 cfs of groundwater spring flow within the reach. The associated cool water input from the bypassed reach during the summer, combined with the fluctuation in discharge from the J.C. Boyle powerhouse during normal operations, results in an increase in the daily water temperature range in the Klamath River in the peaking reach (figure 3-23, top plot). The diurnal pattern of water temperature variation is similar to sites not affected by peaking operation. The range of daily water temperature variation below the powerhouse is greatly reduced, relative to unaffected sites, under conditions of constant daily discharge (figure 3-23, lower plot).

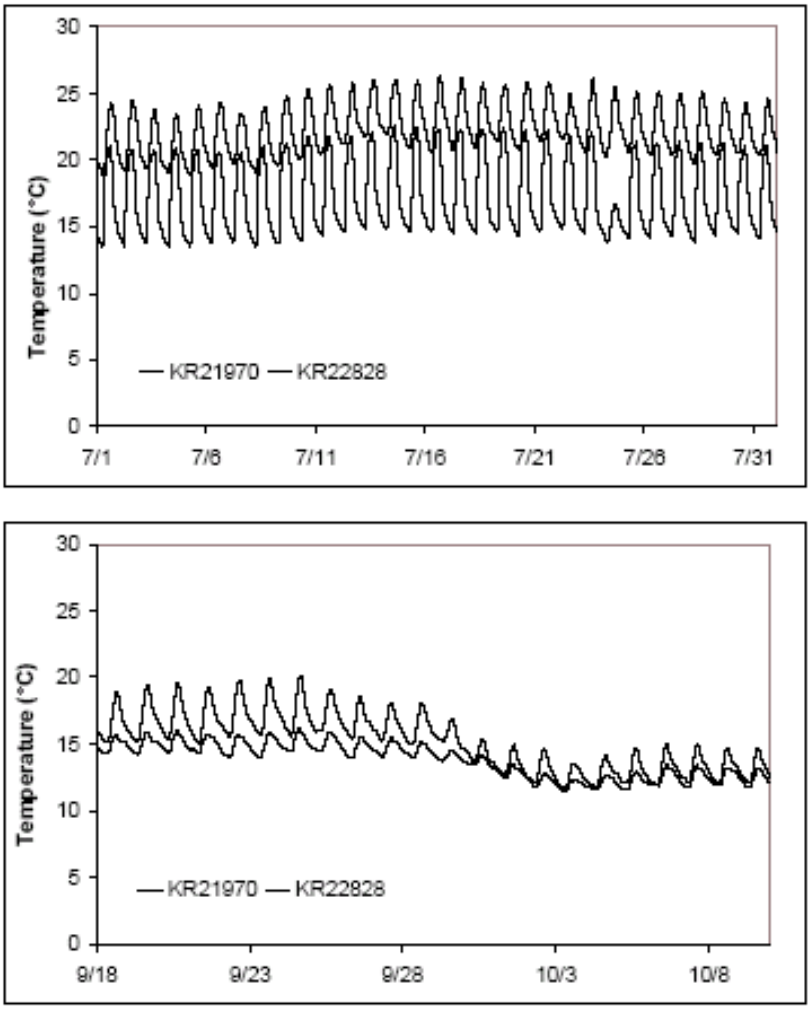
Table 3-26. Average water temperature data for stream reaches within the Klamath River Basin affected by project operation, 2001–2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff).

	Average Monthly Temperature (°C)								
Station	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
Upper Klamath Lake at Freemont St. Bridge	7.3	18.6	12.9		20.4		21.1		
Link River[a]	7.7	10.2	12.8	18.6	22.3	21.4	17.5	13.1	5.6
Klamath Irrigation Project[b]			12.9	18.4	22.2	22.3	18.4	12.5	6.7
Keno reservoir[c]	7.8	9.4	12.9	18.7	22.4	20.8	18.0	12.8	7.3
Klamath River below Keno dam	8.2	10.6	13.7	19.9	23.2	21.1	16.9	14.1	5.6
Klamath River above J.C. Boyle reservoir	8.9	11.2	13.5	20.3	22.2	21.1	16.6	14.3	5.5
J.C. Boyle reservoir at log boom (top 8m)	7.7	11.9	13.5	19.7	21.9	22.5	17.2	12.8	6.2
J.C. Boyle bypassed reach, directly below J.C. Boyle dam	7.7	11.2	14.4	20.7	23.3	21.7	16.5	13.5	6.1
J.C. Boyle bypassed reach (bottom of reach)	9.7	10.8	12.0	14.8	15.8	14.9	12.7	12.0	9.0
J.C. Boyle powerhouse tailrace	7.9		13.7	13.1	22.0	21.8	16.7		11.2
Klamath River near state line (peaking reach)			12.8		18.7		14.0		
Klamath River below state line (peaking reach)			12.8		21.1		15.2		
Klamath River above Shovel Creek (peaking reach)	8.0	9.9	16.6	19.0	19.3	18.5	15.2	11.4	7.1
Copco reservoir (top 8 m) near Copco	7.2	12.1	15.1	19.8	21.9	22.2	18.1	15.3	9.1
Copco reservoir outflow	7.6	11.3	15.0	19.8	21.4	21.4	17.6	15.2	8.9
Fall Creek	9.8	8.8	10.2	12.7	12.5	13.3	10.1	11.1	8.9
Jenny Creek	6.4	11.7	14.5	19.6	22.2	22.5	19.5	16.2	10.5
Iron Gate reservoir (top 9 m) near Hornbrook	6.4	11.7	14.9	19.7	22.3	22.6	19.2	16.2	10.6
Iron Gate dam outflow			17.0	23.2	25.2	24.5	17.8	15.9	10.8
Klamath River upstream of Shasta River	8.0	5.4	10.8	16.7	20.8	20.7	13.0	13.1	7.2

[a] Sampling points include Link River near East Side powerhouse and Link River at mouth.

[b] Sampling points include: Lost River diversion canal at Klamath River, Klamath Straits drain pumping plant F, and Klamath Straits drain 200 feet downstream of pumping plant F. During March and April, only a single temperature reading was taken, and we do not consider those values to be representative of the average monthly inflow from the Klamath Irrigation Project; consequently, we do not report them.

[c] Sampling points include south-side bypass bridge, Miller Island boat ramp, upstream of Klamath Straits drain, between Klamath Straits drain and Keno dam, Keno Bridge (Highway 66), and Keno dam log boom.



Note: KR22828 (upper curve in both plots) – Klamath River above J.C. Boyle reservoir, KR21970 (lower curve in both plots) – Klamath River at the USGS gage below J.C. Boyle powerhouse.

Figure 3-23. Water temperatures measured above and below the J.C. Boyle development during peaking operation (top) and during non-peaking flow (bottom), 2002. (Source: PacifiCorp, 2004a)

PacifiCorp's vertical temperature profiles near the dams at Copco and Iron Gate reservoirs are based on continuously recording meters placed at 1 meter intervals from the surface to near the bottom. The profile data show seasonal (spring through fall) thermal stratification of both reservoirs into three layers: (1) the warm, upper layer referred to as the epilimnion; (2) the metalimnion, which has a strong thermal gradient; and (3) the cold, deep hypolimnion. The epilimnion begins to form in early spring, reaching maximum temperatures approaching 25°C during late July, and then gradually cools to winter minimum temperatures typically around 5°C. Year-round temperatures in the deeper portions (the hypolimnion when the reservoir stratifies) of Iron Gate reservoir typically remain below 10°C. The depth of the metalimnion varies by season, expanding as surface temperatures rise. By mid-summer, the depth of the metalimnion is around 50 feet in both Copco and Iron Gate reservoirs. Thermal stratification begins to break down by October (figure 3-24) and by November, relatively uniform temperatures, generally between 6 and 8°C, exist throughout the water column in Copco and Iron Gate reservoirs.

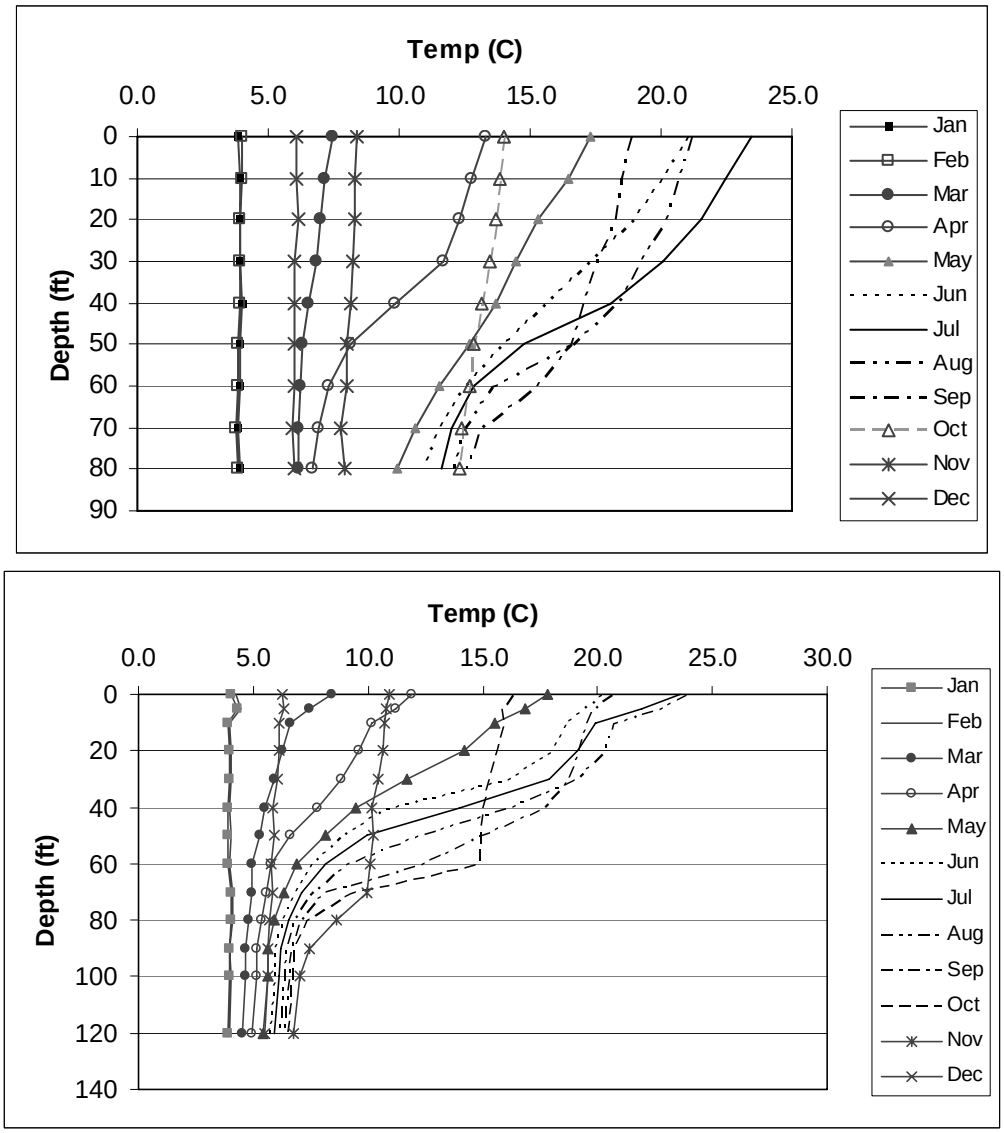


Figure 3-24. Average monthly temperature profiles for Copco (2002-top) and Iron Gate (2001-bottom). (Source: PacifiCorp, 2004a, as modified by staff)

The surface waters of Copco and Iron Gate reservoirs are also 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 thermal gradient.

The bottom of the Copco powerhouse intake structure is about 32 feet below full pool, and the bottom of the Iron Gate intake structure is about 35 feet below full pool. This results in water that passes through the Copco and Iron Gate powerhouses typically originating from the epilimnion during periods when the reservoirs are stratified. Figure 3-25 illustrates the close correlation of the water temperature discharged from the Iron Gate powerhouse to the water temperature measured 10 feet below the surface (epilimnetic water) immediately upstream of Iron Gate dam during the late fall and early spring months. Examination of PacifiCorp profile data indicates that, during the summer and early fall months when the reservoir is stratified, temperatures in the outfall are comparable to (within a few degrees of) water at depths between 10 and 30 feet in Iron Gate reservoir.

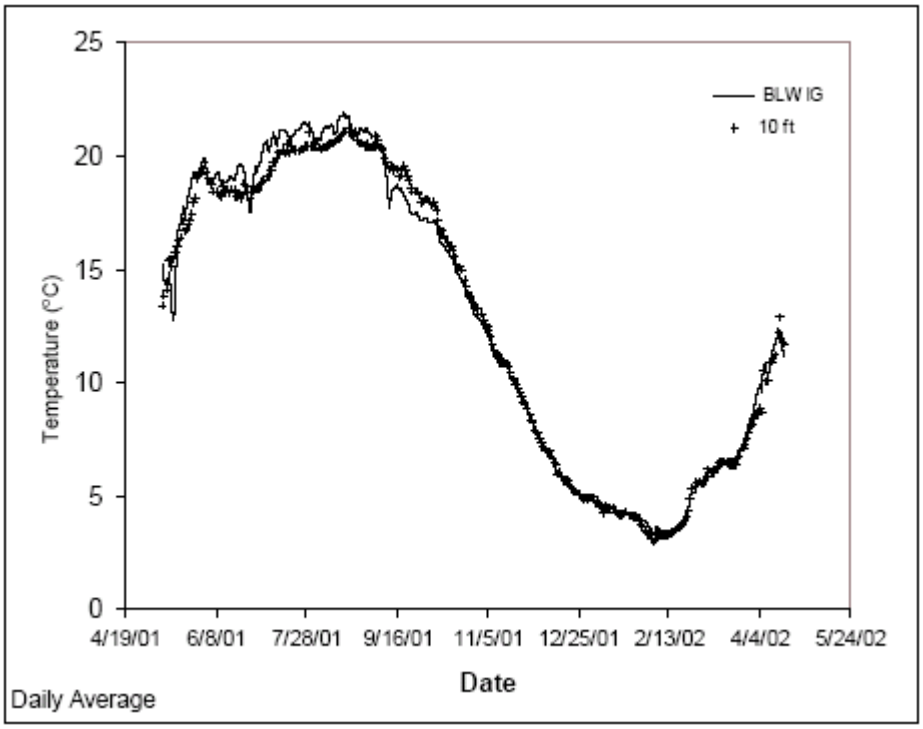


Figure 3-25. Daily average water temperature data from below Iron Gate dam and from a depth of 10 feet in the Iron Gate reservoir. (Source: PacifiCorp, 2004a)

PacifiCorp monitored the temperatures in Fall and Jenny Creeks in 2002 and Spring Creek in 2004 as part of the relicensing sampling effort to characterize the thermal regime. Fall Creek is generally cold year-round and did not exceed 14°C degrees during the summer. Temperatures in Jenny Creek experience strong seasonal variability. Monthly sampling results indicate that the creek warms from less than 10°C in the spring to above 20°C in July and August (see table 3-26), which corresponds to the period of the lowest flows of the year. The 7-day average daily maximum in Jenny Creek above the Spring Creek confluence exceeded 25°C during the warmest part of the year. PacifiCorp monitoring in Spring Creek below the diversion point indicated that temperatures never reached 20°C (PacifiCorp, 2004i). PacifiCorp concluded that, when it stopped diverting water from Spring Creek, water temperatures decreased by between 1 and 2°C in Jenny Creek below the Spring Creek confluence with Jenny Creek; but that the actual benefit to Jenny Creek appears localized.

Numerous entities (PacifiCorp, EPA, FWS, Bureau of Land Management, NCRWQCB, and others) have collected water quality data (including hourly temperature data) pertaining to the Klamath River over the last 5 years which has been compiled into a single database for the Klamath River TMDL.[56] Figures 3-26 through 3-29 show water temperature trends based on hourly data for important sites below Iron Gate for the last 5 years. Summary statistics compiled by the EPA indicate that in June, water temperatures at locations between Iron Gate dam and above the confluence with the Scott River range from about 16 to 22°C, while in July, temperatures range from 16 to 26°C. In August the minimum temperatures are higher but the maximum temperatures are lower than in July.

[56]Section 303(d) of the Clean Water Act requires that states establish a TMDL for any waterbody designated as water quality limited (CWA 303[d] list). TMDLs are written plans with an analysis that establishes what steps will be taken so that waterbodies will attain and maintain water quality levels specified in water quality standards.

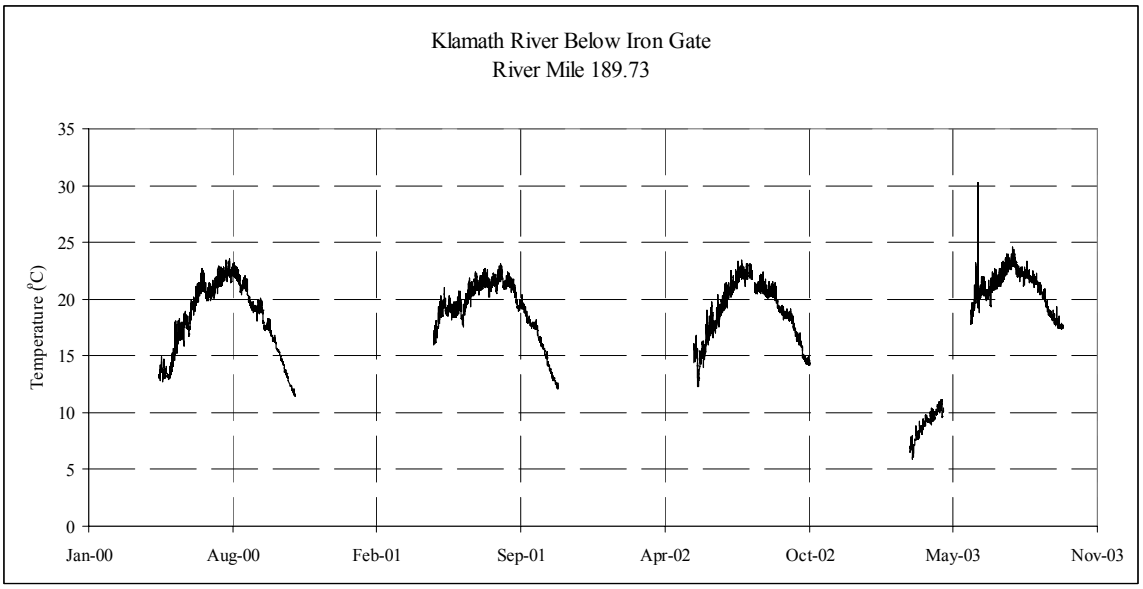


Figure 3-26. Temperature trends based on hourly data in the Klamath River immediately below Iron Gate dam. (Source: Tetra Tech, 2004a, as modified by staff)

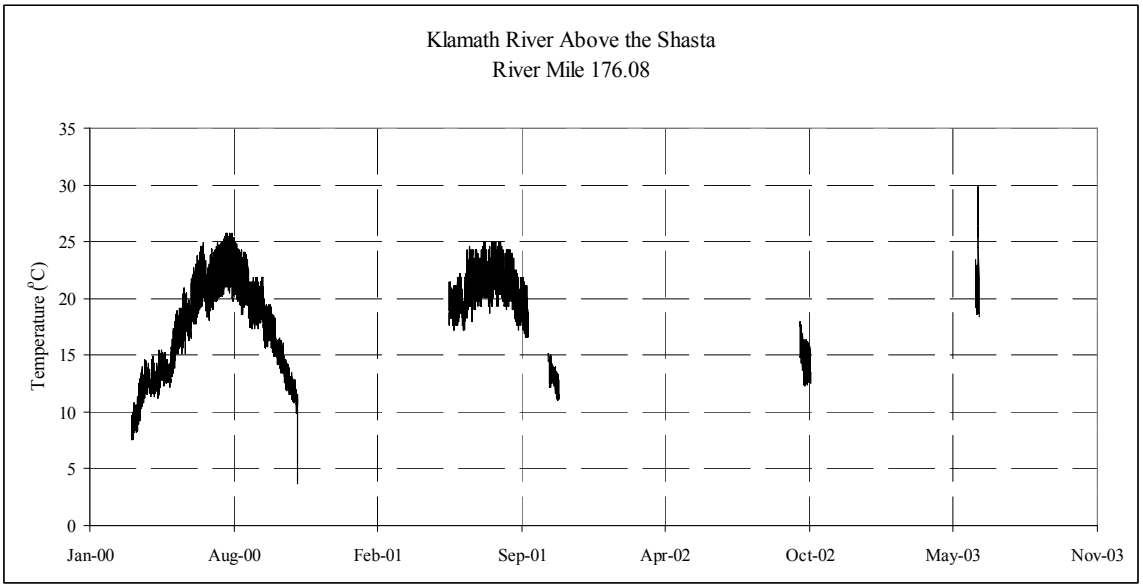


Figure 3-27. Temperature trends based on hourly data in the Klamath River above the Shasta River confluence. (Source: Tetra Tech, 2004a, as modified by staff)

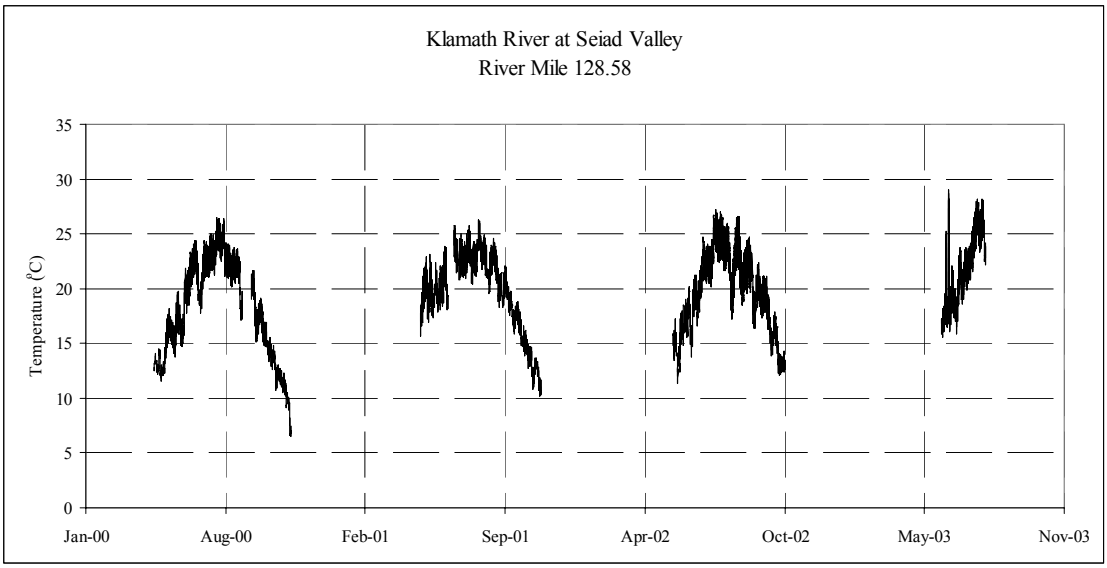


Figure 3-28. Temperature trends based on hourly data in the Klamath River at Seiad Valley. (Source: Tetra Tech, 2004a, as modified by staff)

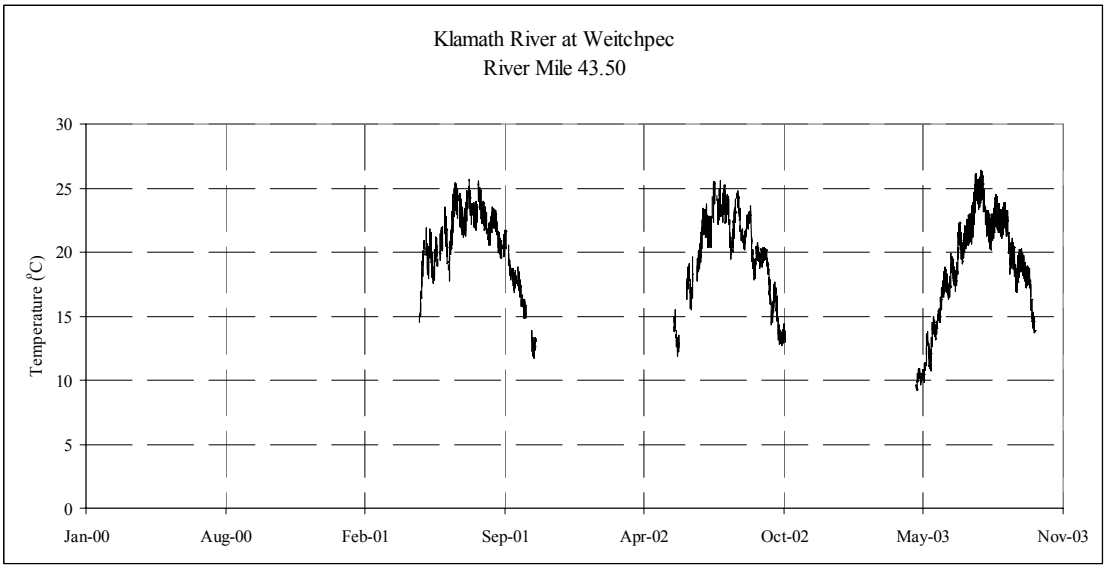


Figure 3-29. Temperature trends based on hourly data in the Klamath River at Weitchpec (RM 43.5). (Source: Tetra Tech, 2004a, as modified by staff)

Dissolved Oxygen

Generally, average DO concentrations from near-surface samples taken in March, April, May, and November comply with applicable criteria; however, seasonal concentrations are quite variable (table 3-27). DO concentrations in Upper Klamath Lake respond to the primary production and respiration needs of algal blooms and biological oxygen demand from aerobic decomposition or organic material in the water, and to a lesser extent, the bottom substrate. Low DO levels in Upper Klamath Lake have been associated with declining algal blooms, typically in later summer and early fall (Perkins et al., 2000). DO also varies daily in response to photosynthesis and respiration of aquatic macrophytes and algae. Figures 3-30 through 3-33 show DO seasonal and interannual trends based on hourly data at select locations within and below the project.

Table 3-27. Average DO concentration for stream reaches and the top 9 meters of reservoirs within the Klamath River Basin affected by project operation, 2001–2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)

	Average Monthly DO (mg/L) (sample size)								
Station	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
Upper Klamath Lake at Freemont St. Bridge.	10.5 (1)	11.7 (1)	9.8 (5)		7.1 (3)		8.0 (2)		
Link River[a]	10.8 (1)	9.7 (2)	9.4 (31)	8.7 (24)	6.8 (25)	6.5 (23)	9.2 (24)	9.3 (22)	11.5 (2)
Klamath Irrigation Project[b]		10.0 (1)	7.5 (9)	5.5 (6)	2.2 (12)	2.3 (8)	3.9 (7)	10.7 (8)	
Keno reservoir[c]	12.7 (5)	6.3 (8)	8.9 (63)	8.2 (65)	4.9 (98)	4.5 (72)	6.5 (67)	5.5 (69)	8.0 (4)
Klamath River below Keno dam	10.9 (1)	10.4 (2)	9.9 (6)	8.8 (3)	6.8 (5)	7.4 (2)	9.2 (5)	7.1 (3)	10.9 (3)
Klamath River above J.C. Boyle reservoir	10.4 (2)	10.4 (2)	9.9 (7)	8.6 (3)	7.3 (4)	8.2 (3)	8.7 (5)	8.3 (3)	12.5 (4)
J.C. Boyle reservoir at log boom (top 8 m)	10.1 (5)	9.3 (10)	10.9 (35)	8.0 (15)	7.0 (15)	5.4 (15)	9.2 (31)	8.4 (17)	10.6 (15)
J.C. Boyle bypassed reach, immediately below the dam	11.2 (2)	10.1 (3)	9.2 (5)	8.2 (3)	6.3 (3)	7.7 (3)	9.0 (5)	8.7 (4)	11.8 (3)
J.C. Boyle bypassed reach (bottom of reach)	11.2 (2)	10.8 (2)	10.3 (8)	9.8 (3)	8.9 (6)	9.8 (3)	10.0 (5)	9.4 (3)	11.7 (4)
J.C. Boyle powerhouse tailrace	11.3 (2)		8.6 (77)	10.2 (1)	6.8 (3)	5.3 (1)	8.7 (3)		9.9 (2)
Klamath River near state line (peaking reach)			8.8 (3)		7.3 (4)		7.0 (3)		
Klamath River below state line (peaking reach)			9.9 (3)		7.7 (4)		8.3 (3)		
Klamath River above Shovel Creek (peaking reach)	11.4 (3)	11.2 (3)	10.0 (2)	9.3 (4)	9.3 (4)	9.8 (4)	9.6 (4)	9.5 (4)	11.6 (3)
Copco reservoir (top 8m) near Copco	11.2 (20)	9.7 (25)	9.4 (56)	8.3 (30)	9.5 (35)	9.3 (29)	7.5 (32)	8.4 (26)	9.4 (24)
Copco reservoir	10.6 (2)	9.7 (2)	9.1 (3)	8.5 (3)	6.9 (3)	8.0 (3)	7.4 (4)	7.4 (3)	9.8 (3)
Fall Creek	10.9 (2)	11.3 (1)	10.7 (1)	10.2 (1)	10.6 (1)	10.6 (1)	11.4 (1)	8.6 (1)	11.7 (1)
Jenny Creek	12.0 (2)	12.2 (1)	10.8 (1)	9.4 (1)	9.0 (1)	9.0 (1)	10.6 (1)	8.5 (1)	12.2 (1)
Iron Gate reservoir (top 9m) near Hornbrook	12.1 (22)	9.8 (24)	10.1 (41)	9.0 (26)	7.2 (31)	8.6 (27)	6.6 (31)	7.4 (24)	7.7 (22)
Iron Gate dam outflow	12.2 (3)	10.5 (3)	10.3 (3)	9.5 (4)	8.5 (4)	8.9 (4)	8.1 (4)	7.3 (4)	9.3 (4)
Klamath River upstream of Shasta River			11.2 (1)	10.4 (2)	10.5 (2)	10.2 (2)	9.7 (2)	8.4 (2)	11.5 (2)

[a] Sampling points include: Link River near East Side powerhouse and Link River at mouth.

[b] Sampling points include: Lost River diversion canal at Klamath River, Klamath Straits drain pumping plant F, and Klamath Straits drain 200 feet downstream of pumping plant F.

[c] Sampling points include: south-side bypass bridge, Miller Island boat ramp, upstream of Klamath Straits drain, between Klamath Straits drain and Keno dam, Keno Bridge (Highway 66), and Keno dam log boom.

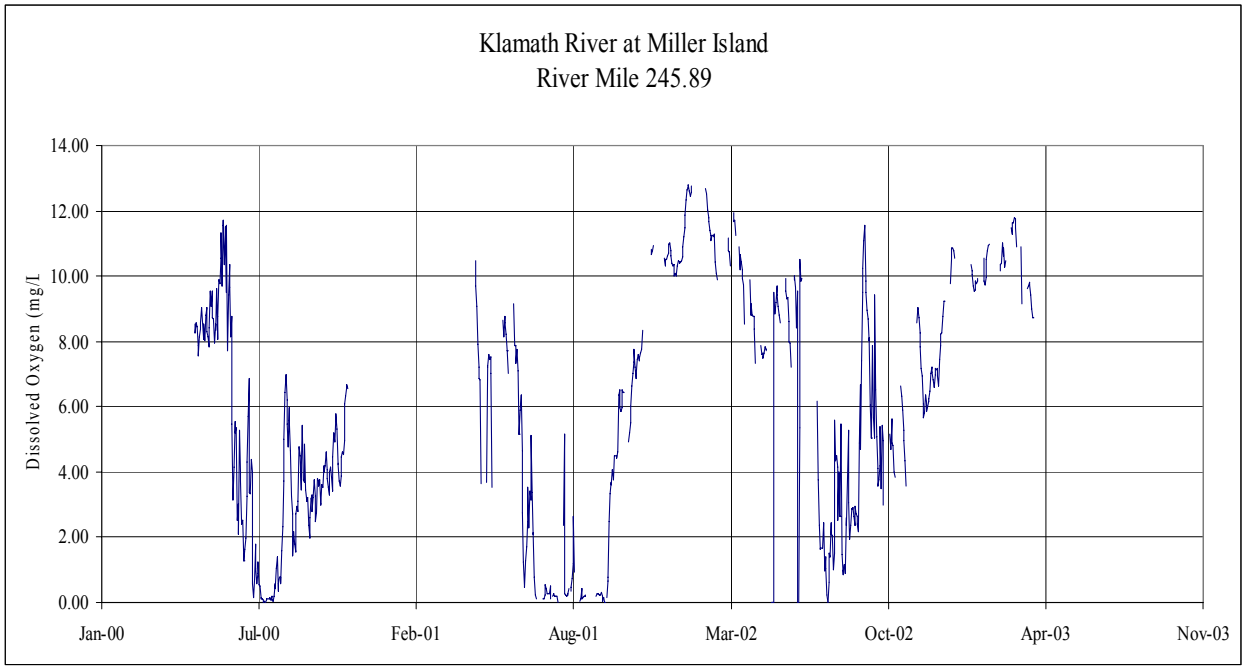


Figure 3-30. Trends in DO concentrations based on hourly data in Keno reservoir at Miller Island. (Source: Tetra Tech, 2004a, as modified by staff)

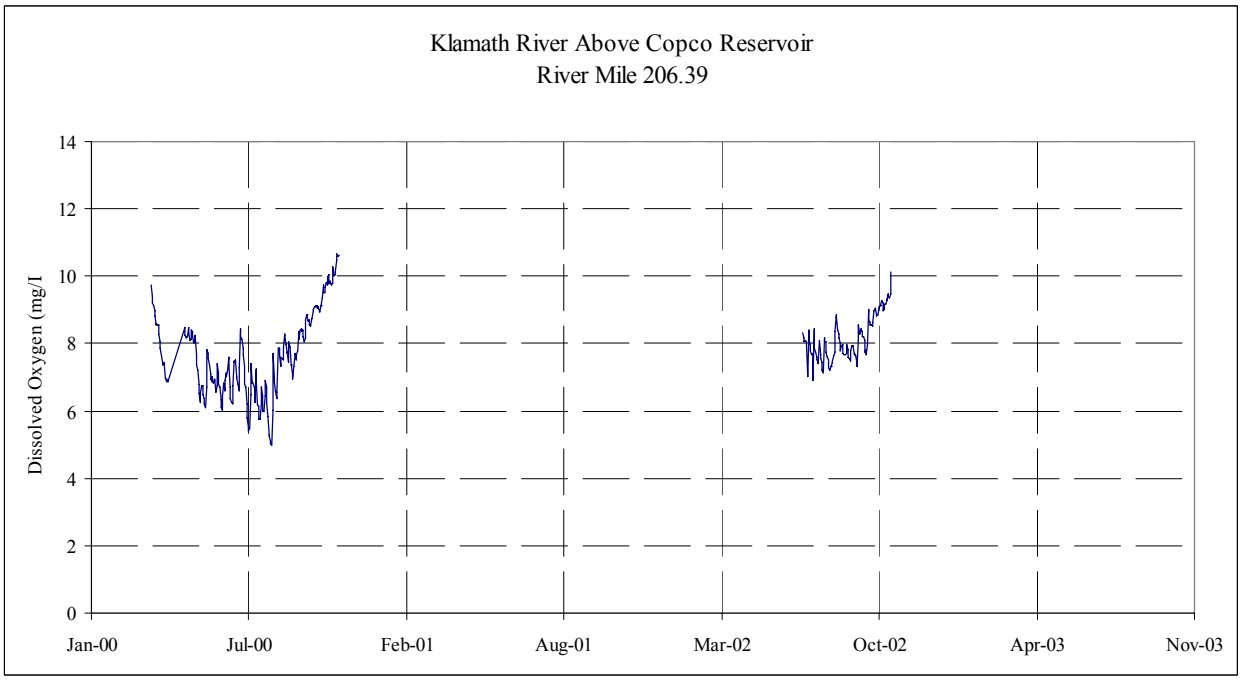


Figure 3-31. Trends in DO concentrations based on hourly data in the Klamath River above Copco reservoir. (Source: Tetra Tech, 2004a, as modified by staff)

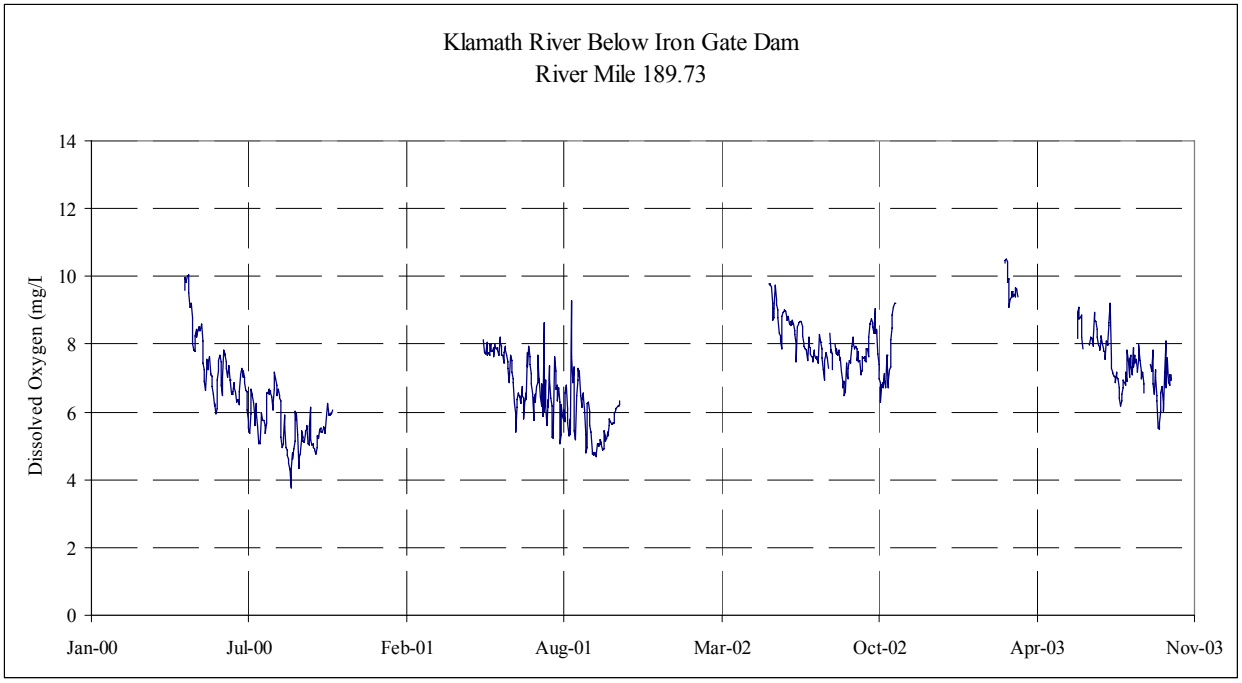


Figure 3-32. Trends in DO concentrations based on hourly data in the Klamath River below Iron Gate dam. (Source: Tetra Tech, 2004a, as modified by staff)

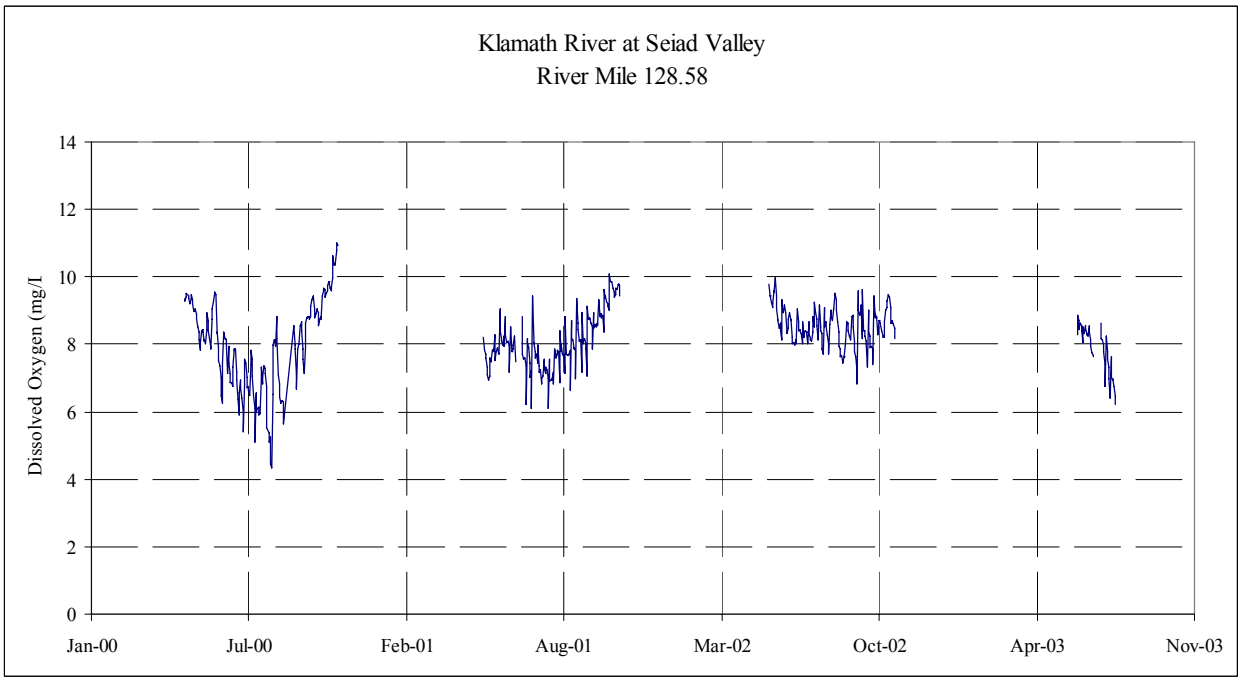


Figure 3-33. Trends in DO concentrations based on hourly data in the Klamath River at Seiad Valley. (Source: Tetra Tech, 2004a, as modified by staff)

Figure 3-30 shows that DO in Keno reservoir during the summer can be less than 4.0 mg/L for extended periods of time regardless of the year, and is also subject to extreme fluctuations. DO in the peaking reach (figure 3-31), downstream of Iron Gate dam (figure 3-32), and at Seiad Valley (figure 3-33) are typically above 4.0 mg/L and do not show the extreme variability within and between years that is evident at Keno reservoir.

PacifiCorp's DO sampling results from Keno reservoir show a year-round longitudinal gradient; DO increases from Link River to RM 241 (near the reservoir mid-point), then decreases to a minimum at RM 238 downstream of Klamath Straits drain, before increasing again toward RM 235, about 2 miles upstream of Keno dam (table 3-28). Overall, DO levels in Keno reservoir from June through September are below 6 mg/L; some sites average below 4 mg/L in July and August.

Table 3-28. Average DO concentration within Keno reservoir, 2001-2004. (Source: PacifiCorp, AIR response and 2005n, as modified by staff)

	Average Monthly DO (mg/L) in Keno reservoir (number of samples in parenthesis)								
Station	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
South-side bypass bridge (RM 250.79)		6.8 (1)	9.0 (11)	7.8 (11)	4.8 (12)	3.7 (12)	5.3 (9)	6.2 (10)	
Miller Island boat ramp (RM 245.89)		5.2 (2)	8.6 (10)	8.5 (12)	4.6 (17)	2.4 (12)	3.7 (12)	3.5 (12)	
Upstream of Klamath Straits (RM 241.48)			9.2 (15)	8.9 (13)	5.6 (22)	7.6 (16)	8.6 (15)	5.6 (14)	
Directly south of hill 4315 (RM 238.28)		5.8 (1)	8.9 (15)	7.4 (14)	3.0 (23)	4.5 (15)	7.8 (14)	6.5 (15)	
Keno bridge (Highway 66) (RM 234.90)	12.7 (5)	7.3 (4)	8.5 (12)	7.9 (11)	3.7 (21)	5.0 (14)	6.7 (15)	6.0 (15)	7.5 (1)
Keno dam at log boom, near surface (RM 233.60)				8.8 (4)	7.1 (3)	3.2 (3)	6.4 (2)	4.7 (3)	6.9 (3)
Keno dam at log boom, near bottom (RM 233.60)				4.4 (3)	3.5 (2)	0.8 (4)	0.8 (5)	4.0 (3)	6.6 (3)

Table 3-29 shows average DO concentrations at three sampling locations within Keno reservoir during May, July, and October 2002. In May, the entire reservoir is fairly well oxygenated but by July the sites in the middle and downstream portions of the reservoir experience low DO concentrations at depth. In October, the reservoir at the Miller Island boat ramp site still experiences low DO concentrations throughout the entire water column while further downstream at RM 238.28 the top 2 meters the average DO concentration is above 9.0 mg/L.

Table 3-29. Average DO concentrations from representative profiles in Keno reservoir during May, July, and October, 2002. (Source: PacifiCorp, 2004a, as modified by staff)

Depth (m)	**Link River (mouth) RM 253.12**			**Miller Island boat ramp RM 245.89**			**Between Klamath Straits Drain and Keno dam RM 238.28**		
	May	**July**	**October**	**May**	**July**	**October**	**May**	**July**	**October**
Surface	9.7 (11)	6.7 (8)	9.0 (6)	8.6 (4)	7.7 (6)	4.1 (4)	9.1 (4)	5.3 (6)	9.2 (4)
1	9.5 (3)	7.6 (3)	9.0 (2)	8.5 (3)	4.9 (3)	3.9 (2)	8.8 (3)	3.3 (3)	9.3 (2)
2	9.4 (2)	6.7 (2)	9.0 (2)	8.6 (2)	3.0 (2)	3.8 (2)	9.1 (2)	2.2 (3)	7.0 (2)
3	9.4 (2)	5.7 (1)	8.7 (2)	8.7 (1)	3.5 (3)	3.4 (1)	9.1 (2)	2.1 (3)	5.2 (2)
4					2.2 (2)	3.3 (1)	9.0 (2)	2.0 (3)	4.5 (2)
5					0.1 (1)	1.1 (2)	8.6 (2)	1.9 (4)	3.0 (3)
6								0.1 (1)	

As shown in table 3-27, DO concentrations were near saturation in the free-flowing reach downstream of Keno dam to Copco reservoir. DO concentrations averaged less than 6.0 mg/L in July and August at the J.C. Boyle reservoir log boom and in August at the J.C. Boyle powerhouse tailrace, which represents water drawn from the J.C. Boyle reservoir in the vicinity of the log boom, and not necessarily representative of the free-flowing reaches from Keno dam to Copco reservoir. Note that table 3-27 presents average DO concentrations based on grab samples that were collected during daylight hours when daily DO concentrations are typically at their highest levels of the day, which also corresponds to when the J.C. Boyle powerhouse releases peaking flows. The operation of J.C. Boyle dam in peaking mode seems to have negligible effect on DO concentrations in the peaking reach because the free-flowing river upstream of J.C. Boyle and the high velocity flows of peaking provide opportunities for aeration. DO concentrations greater than 8.0 mg/L are associated with flows over 1,000 cfs(see figure 3-34).

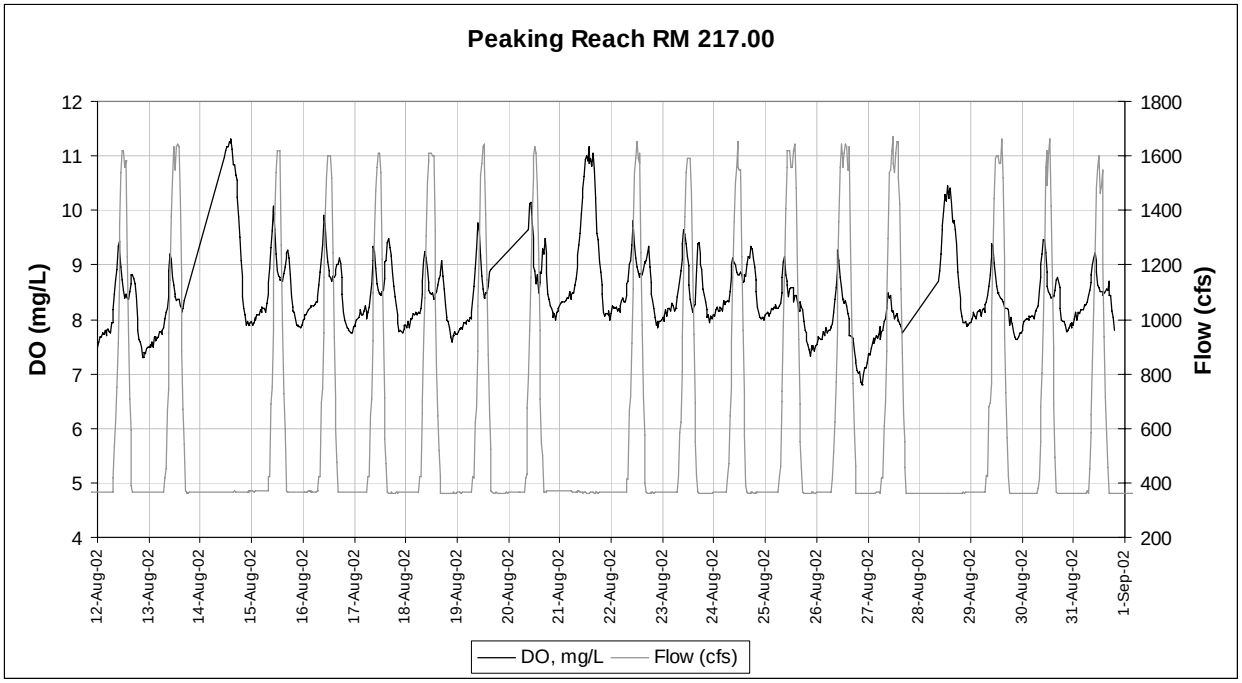


Figure 3-34. Comparison of flows and DO concentrations in the Klamath River (peaking reach) below J.C. Boyle powerhouse in August 2002. (Source: USGS gage no. 11510700 and Tetra Tech, 2004a, as modified by staff)

The thermal stratification in Copco and Iron Gate reservoirs isolates the bottom waters from the rest of the water column. Biological and sediment oxygen demand in Copco (and to a lesser extent in Iron Gate) reservoir in the summer (most likely resulting from aerobic decomposition of dead algae and other organic matter) cause the hypolimnion to lose oxygen.

Figure 3-35 shows DO concentrations near the surface of both reservoirs are high and near saturation for the corresponding water temperatures. However, as the summer progresses, the DO gradient between top and bottom becomes greater until the lake mixes in November. DO concentrations are similar throughout the water column as the water remains isothermal until around March when stratification again begins to isolate the bottom waters.

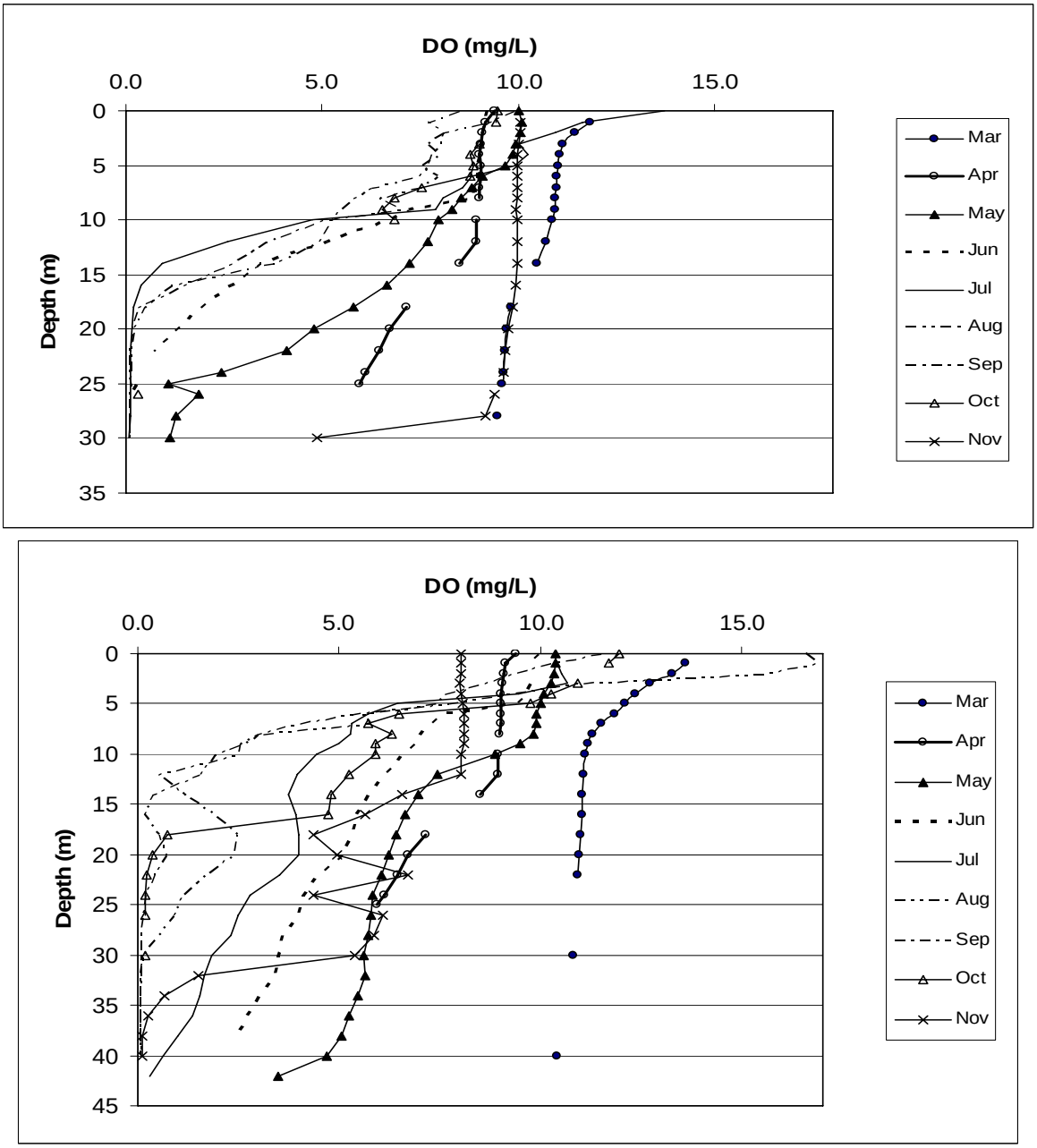


Figure 3-35. Average DO concentrations at 1 meter intervals in Copco (top) and Iron Gate (bottom) reservoirs from March through November, 2002. (Source: PacifiCorp, 2004a, as modified by staff)

At 10 meters in Copco reservoir (approximate depth of intakes), DO concentrations in the water ranged between 4.7 and 6.8 mg/L in June, July, August, and September 2002. In Iron Gate reservoir, DO measurements taken during the same time period at 11 meters (approximate intake depth) ranged from 1.9 mg/L (September) to 6.6 mg/L (June). PacifiCorp recorded average values below the state instantaneous objective of 8.0 mg/L in October in the outflow from Iron Gate dam (see table 3-27). Average DO concentrations measured by PacifiCorp in the outflow from March through November ranged from 7.3 to 12.2 mg/L (six average monthly values were below 10 mg/L, which is at the limit of the annual state water quality objective; see table 3-25) with average values between June and October around 8.5 mg/L. The lowest values were observed in September and October (see table 3-27). Between the Iron Gate dam outflow and Shasta River, the water becomes oxygenated; average values in the Klamath River, reported by PacifiCorp, above the confluence with the Shasta River for June, July, and August were above 10 mg/L, with a minimum instantaneous value of 8.2 mg/L. The average DO values for September and October were 9.7 and 8.4 mg/L, respectively. In contrast, DO trends based on hourly data indicated that few, if any, DO concentrations exceeded 10 mg/L during each of the 4 years of data collection reported by TetraTech (2004a) and shown in figures 3-32 and 3-33 (data were not collected during winter months).

Nutrients

Water quality in the Klamath River is strongly influenced by the amount of nutrients (particularly the various forms of nitrogen and phosphorous) and algae entering project waters from Upper Klamath Lake. Sediment core studies by Eilers et al. (2001) concluded that Upper Klamath Lake has historically been a very productive lake with high nutrient concentrations and blue-green algae for the last 1,000 years. Walker (2001) concludes, based on sediment core analysis, that over the past 100 years the water quality of Upper Klamath Lake has changed substantially as consumptive water use practices (e.g., irrigation, municipal uses) and accompanying changes in land use practices throughout the upper Klamath and Lost River watersheds have increased. Mobilization of phosphorus from agriculture and other non-point sources (Walker, 2001) seems to have pushed the lake into its current hypereutrophic state, which includes algal blooms reaching or approaching theoretical maximum abundance. Also, algal populations now are strongly dominated by a single blue-green algal cyanobacteria species, *Aphanizomenon flos-aquae* rather than the diatom taxa that dominated blooms before nutrient enrichment (Kann, 1998; Eilers et al., 2001). Blooms of the toxic blue green algae *Microcystis aeruginosa* have been documented in Upper Klamath Lake (Environmental Health Perspectives, 1999), and this species has been found in the Klamath River downstream from Upper Klamath Lake, including in Copco and Iron Gate reservoirs.

The TMDL for Upper Klamath and Agency lakes developed in 2002 by Oregon Environmental Quality and approved by EPA identifies these interconnected lakes as hypereutrophic. They have high nutrient loading which 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. The TMDL identifies phosphorous loading targets as the primary strategy in improving water quality.

Considerable water quality data are available for Upper Klamath Lake, particularly from the past decade as Oregon Environmental Quality prepared the Upper Klamath Lake TMDL. Total phosphorus concentrations in the lake and its outflow to the Klamath River can exceed 300 µg/L (figure 3-36).

Total phosphorus in Upper Klamath Lake tends to rise in spring and remain elevated through summer (figure 3-37). Oregon Environmental Quality (2002b) reports that the spring rise results mainly from increases in phosphorus loading during spring runoff events from sources external to the lake and that continued high concentrations in outflow during summer is the result of internal loading to lake waters from nutrient rich sediments and algal bloom die-offs. Oregon Environmental Quality reports that the fall is when phosphorous levels drop due to phosphorous settling out of the water column into the sediments. On an average annual basis, external sources make up 39 percent and internal sources 61 percent of the total phosphorus load (Oregon Environmental Quality, 2002b).

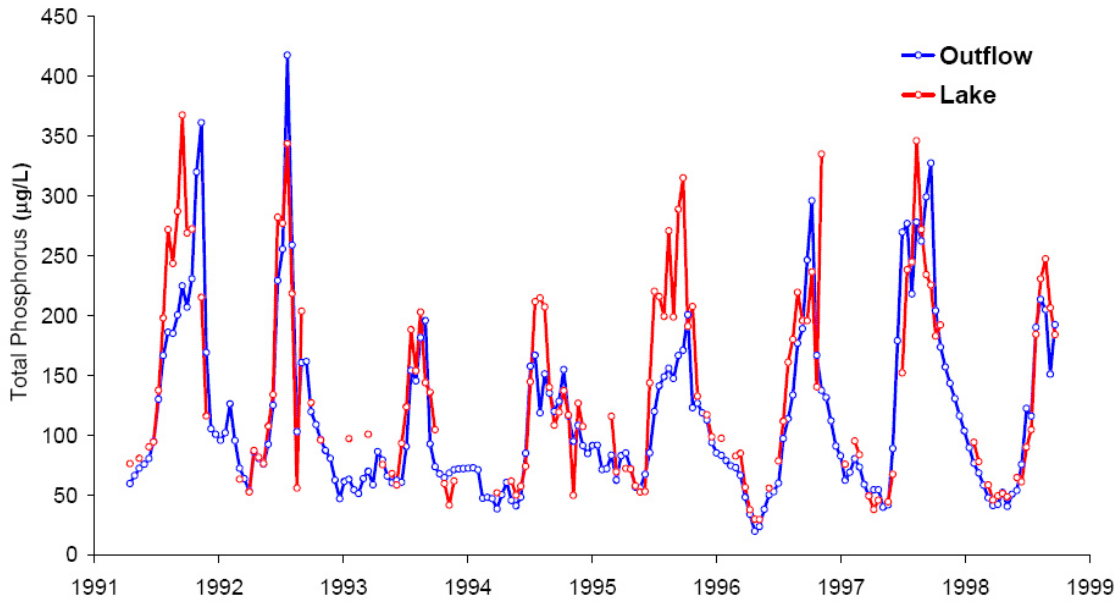


Figure 3-36. Total phosphorous concentrations measured during 1991 to 1999 in Upper Klamath Lake and its outflow. (Source: Oregon Environmental Quality, 2002b, as modified by staff)

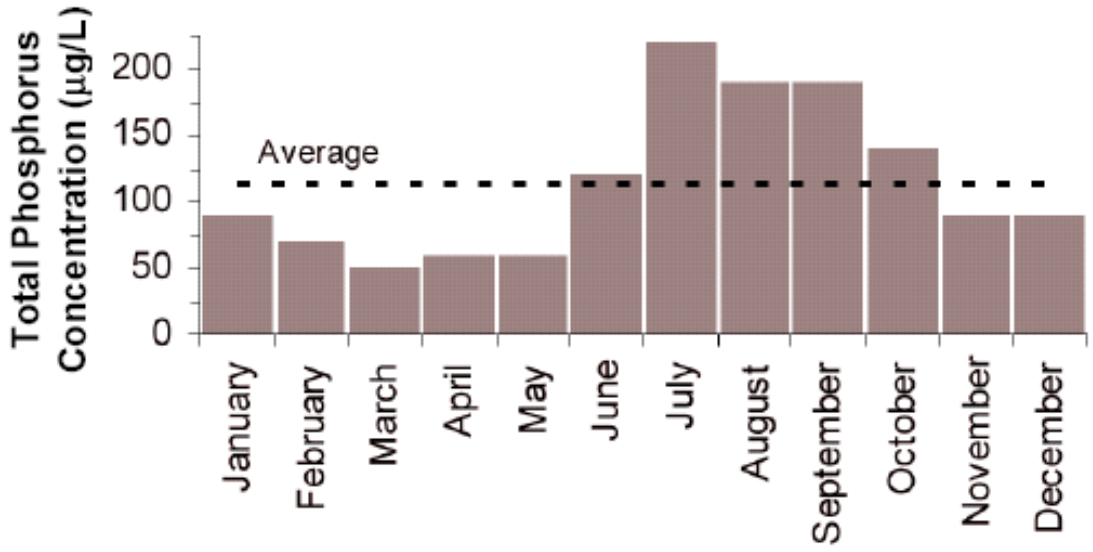
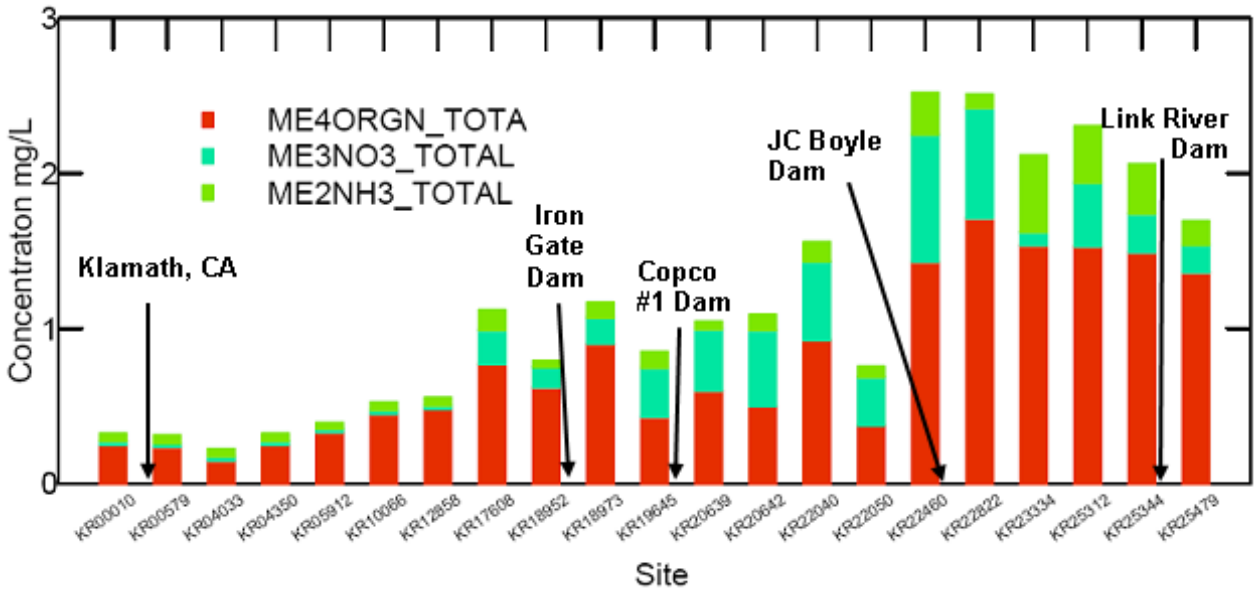


Figure 3-37. Upper Klamath Lake mean total phosphorus concentrations (1991 – 1998). (Source: Oregon Environmental Quality, 2002b)

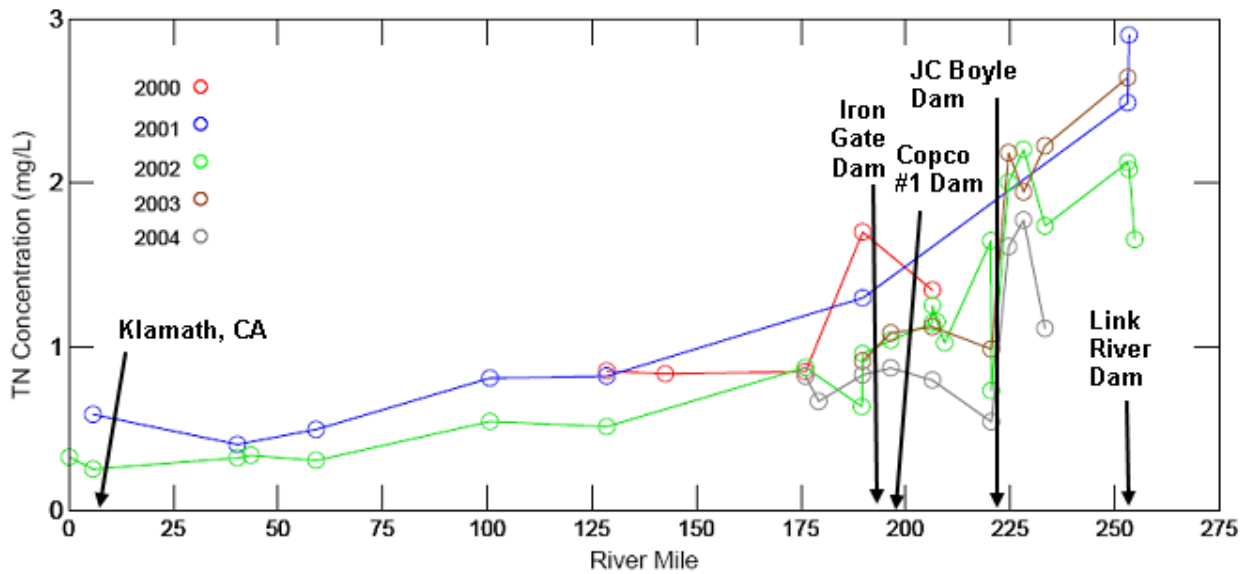
Upper Klamath Lake is also a seasonally substantial source of nitrogen (Kann and Walker, 2001; Oregon Environmental Quality, 2002b). The primary source for this nitrogen loading is from nitrogen fixation by *Aphanizomenon*. Oregon Environmental Quality (2002b) reports that the average outflow total nitrogen load was about 3.5 times the inflow load from 1992 to 1999. Another potential internal source is the mobilization of inorganic nitrogen from lake sediments during anaerobic bacterial decomposition.

Water quality in the project-affected reaches of the Klamath River exhibits the characteristics of its source waters—Upper Klamath Lake and agricultural returns into Keno reservoir. Agricultural returns have substantial amounts of sediments, nutrients, and higher temperatures resulting from its course through agricultural fields and canals. Municipal and industrial inflows to Keno reservoir, which represent about 1 percent of the inflow, are additional sources of nutrients. Kier Associates (2006) summarizes nutrient data in the Klamath River by stating that nutrient concentrations generally decline as the river flows downstream and lists the reasons for this as (1) dilution by springs and tributary inflows; (2) uptake by aquatic vegetation; and (3) denitrification (whereby nitrates are reduced to gaseous nitrogen). Inorganic nitrogen (nitrate and ammonia, shown as two shades of green in figure 3-38 and the form readily available for plant uptake), is present in high levels throughout the upper Klamath River and diminishes in a longitudinal gradient downstream (Kier Associates, 2006). Figures 3-39 and 3-40 show the total concentrations of nitrogen and phosphorus. Although there is noticeable variability between years, the longitudinal gradient persists each year.



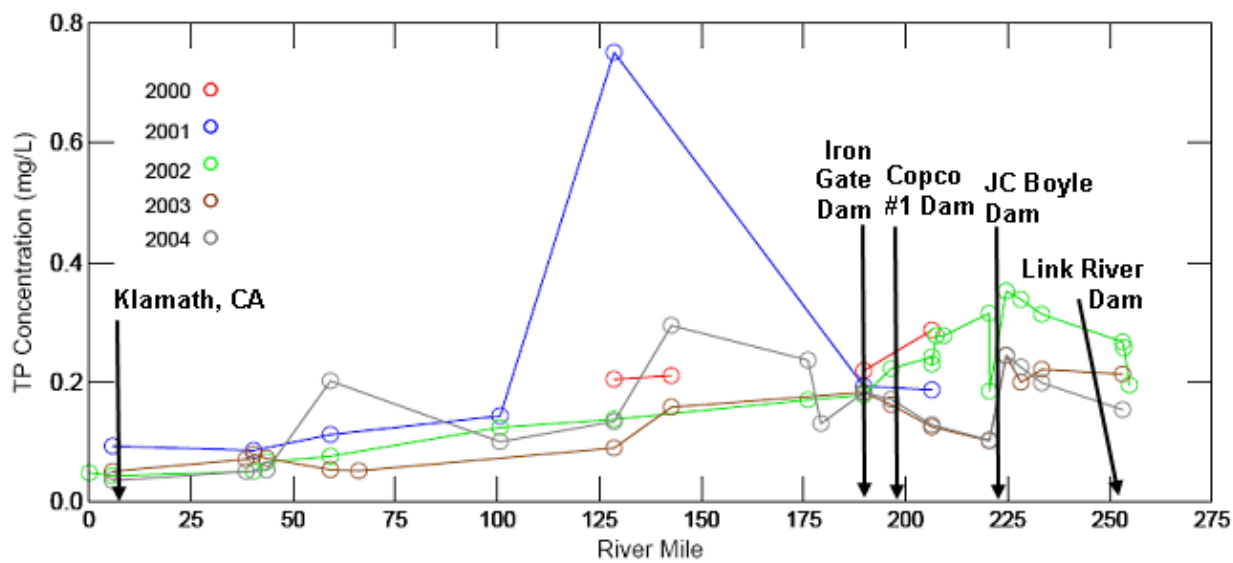
Note: The total height of the bars is total nitrogen concentration and the colors represent the three major forms of nitrogen (ME_4ORGN, TOTAL), nitrate (ME_3NO_3 TOTAL), and ammonia (ME_2NH_3 TOTAL).

Figure 3-38. Longitudinal gradient in average nitrogen concentrations in the Klamath River from Link River to the estuary in August 2002. (Source: Kier Associates, 2006)



Note: Sites with less than three measurements in a summer were excluded from this graph.

Figure 3-39. Longitudinal profile of mean summer total nitrogen concentrations in the Klamath River mainstem sites for the years 2000-2004 (reservoirs excluded). (Source: Kier Associates, 2006)



Note: Sites with less than three measurements in a summer were excluded from this graph.

Figure 3-40. Longitudinal profile of mean summer total phosphorus concentrations in the Klamath River mainstem sites for the years 2000-2004 (reservoirs excluded). (Source: Kier Associates, 2006)

Figure 3-41 shows PacifiCorp monthly total phosphorus and orthophosphate sampling data within Keno reservoir taken in June, July, August, and September from 2001through 2004. The data show elevated total phosphorous and orthophosphate inputs from the Klamath Straits drain, as measured at pumping plant F. Overall, total phosphorous levels in this reach are high and continue to support extensive algae abundance during the summer months (see later discussion of algae).

Downstream of Keno dam, including the J.C. Boyle development, the Klamath River generally becomes steep and free flowing, providing good mixing and aeration. PacifiCorp sampling results from the top and bottom of J.C. Boyle reservoir near the dam show no substantial difference in total phosphorous, orthophosphate, nitrate, and ammonia.

Mean total phosphorus concentrations from summer sampling is lower in the J.C. Boyle bypassed reach than at sites upstream, and is due primarily to the dilution by spring water low in nutrients in this reach. Mean total phosphorus concentrations reach the highest levels observed in PacifiCorp's sampling program in the bottom of Copco reservoir (figure 3-42, top). Mean orthophosphate phosphorus concentration, although slightly lower in the J.C. Boyle bypassed reach, is not markedly different in the peaking reach or waters entering Copco reservoir than it is below Keno dam (figure 3-42, bottom). Contrary to the trends highlighted by Kier Associates, a USGS water quality study initiated in 1996 (Campbell, 2001) to characterize water quality as it affects anadromous fish production concluded that both total and ortho-phosphorus concentrations have a tendency to increase in a downstream direction from Keno to Iron Gate dams.

Oregon Environmental Quality included the Klamath River 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 PacifiCorp concluded that a number of sites exceeded the EPA-recommended ammonia toxicity criterion for un-ionized ammonia.[57] Thirty-four percent (178 of 519) of ammonia samples throughout the project area in 2000 through 2002 exceeded the acute toxicity criterion. Most of those samples (64) were from Keno reservoir and water near the bottom of J.C. Boyle (19), Copco (22), and Iron Gate reservoirs (13).

According to PacifiCorp's sampling results, nitrogen undergoes somewhat more complex changes than phosphorus. Figure 3-43 shows the minimum, mean, and maximum nitrate and ammonia concentrations in Keno reservoir. Mean concentrations of ammonia are high in the upstream portion of Keno reservoir and decrease downstream with distance from Keno dam (figure 3-44) with the exception of the bottom of Copco reservoir. The pattern of mean nitrate nitrogen concentration is the converse of ammonia nitrogen. Along the Klamath River, nitrate concentrations are quite low in the upper portion of Keno reservoir above Klamath Straits drain and then increase to a high in the bottom of J.C. Boyle reservoir (mean of 0.7 mg/L). Ammonia levels that exceed between 0.232 and 6.06 mg/L on a long-term basis (30-day average continuous concentration) and 0.885 and 32.6 mg/L on a short-term basis (1 hour average) are considered toxic to aquatic life (EPA, 1999). The range of values observed in the peaking reach is fairly narrow (0.1 to 0.8 mg/L) compared to Copco and Iron Gate reservoirs downstream (figure 3-44). Results from the 1996 USGS water quality study (Campbell, 2001) showed that ammonia, total Kjeldahl nitrogen, total nitrogen and total organic nitrogen concentrations showed a strong tendency to decrease in a downstream direction and nitrate concentrations tended to increase in a downstream direction. The USGS conclusion for the nitrogen-based nutrients, specifically ammonia and nitrate nitrogen, shows some inconsistencies with PacifiCorp's results.

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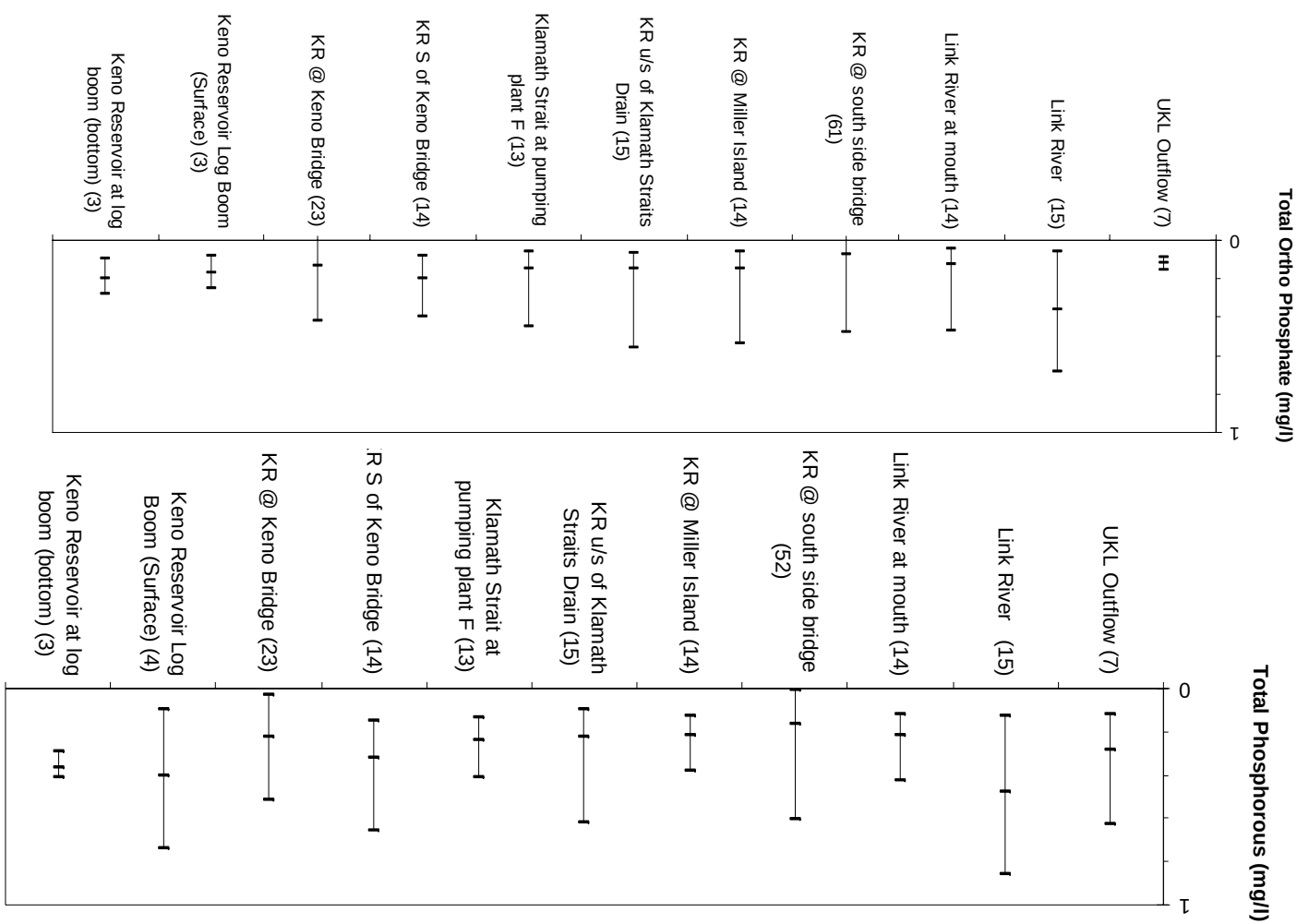
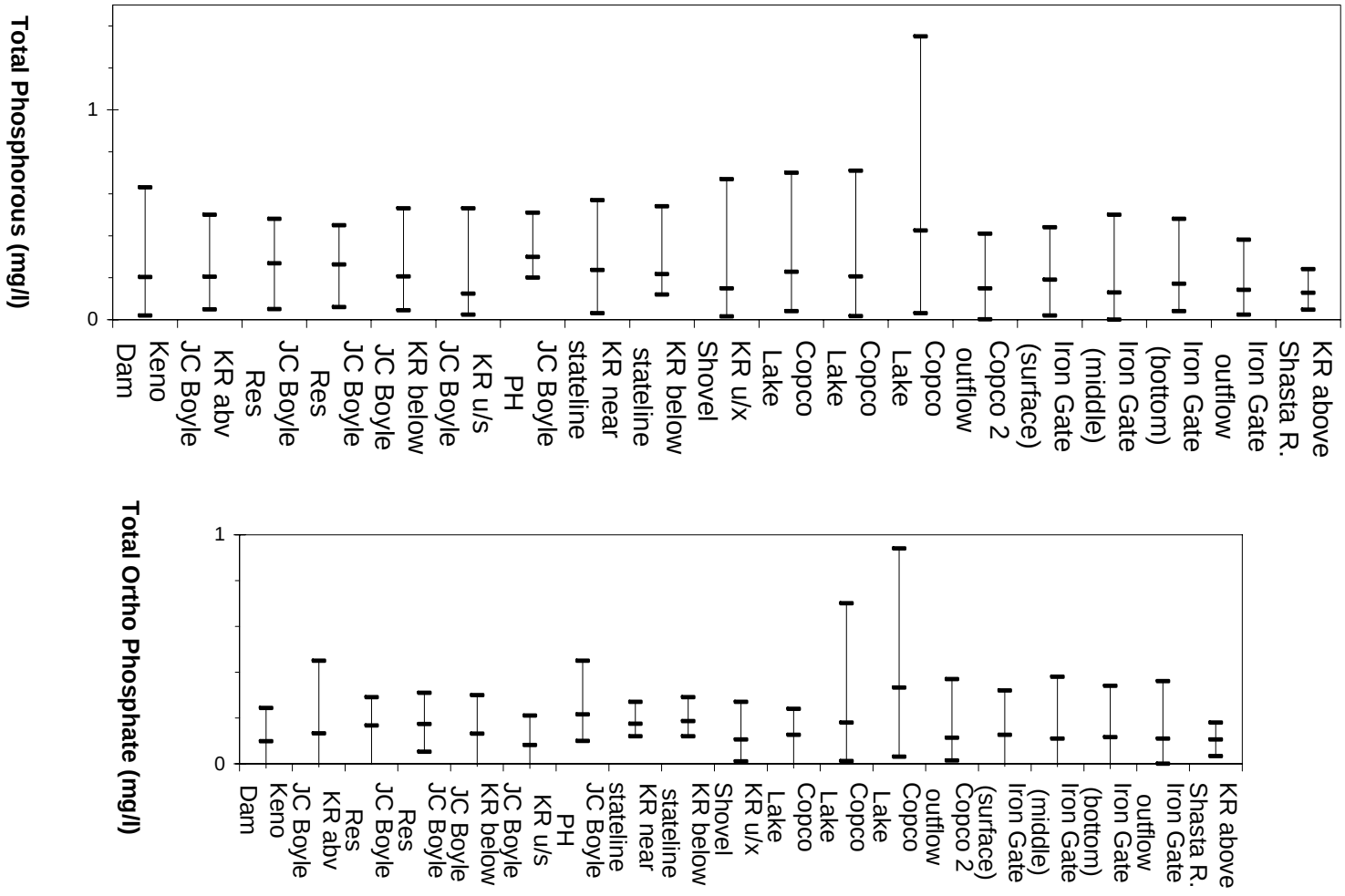
[57]Ammonia toxicity depends on temperature and pH. When salmonids are present, the acute toxicity level is between 0.885 to 32.6 mg/L at 9.0 and 6.5 pH units, respectively. When salmonids are not present, the acute toxicity level is between 1.32 and 48.8 mg/L at 9.0 and 6.5 pH units, respectively. In general, higher temperatures and higher pH values in the water result in lower ammonia toxicity criteria.



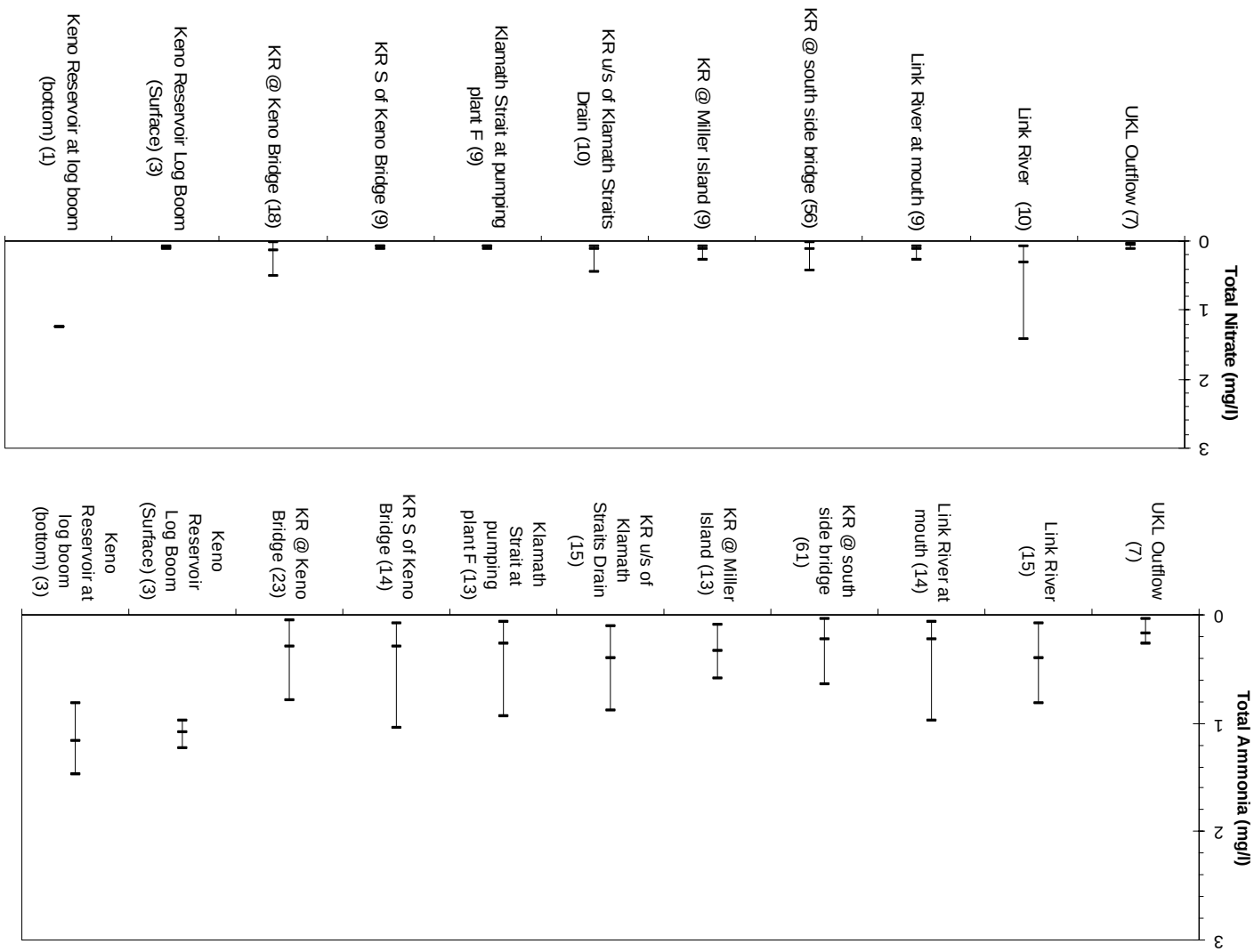
Note: Sample sizes are given in parentheses.

Figure 3-41. Minimum, mean and maximum total orthophosphate (top) and phosphorous (bottom) concentrations (mg/L) in the Klamath River between Upper Klamath Lake and Keno dam during June, July, August, and September 2001-2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)



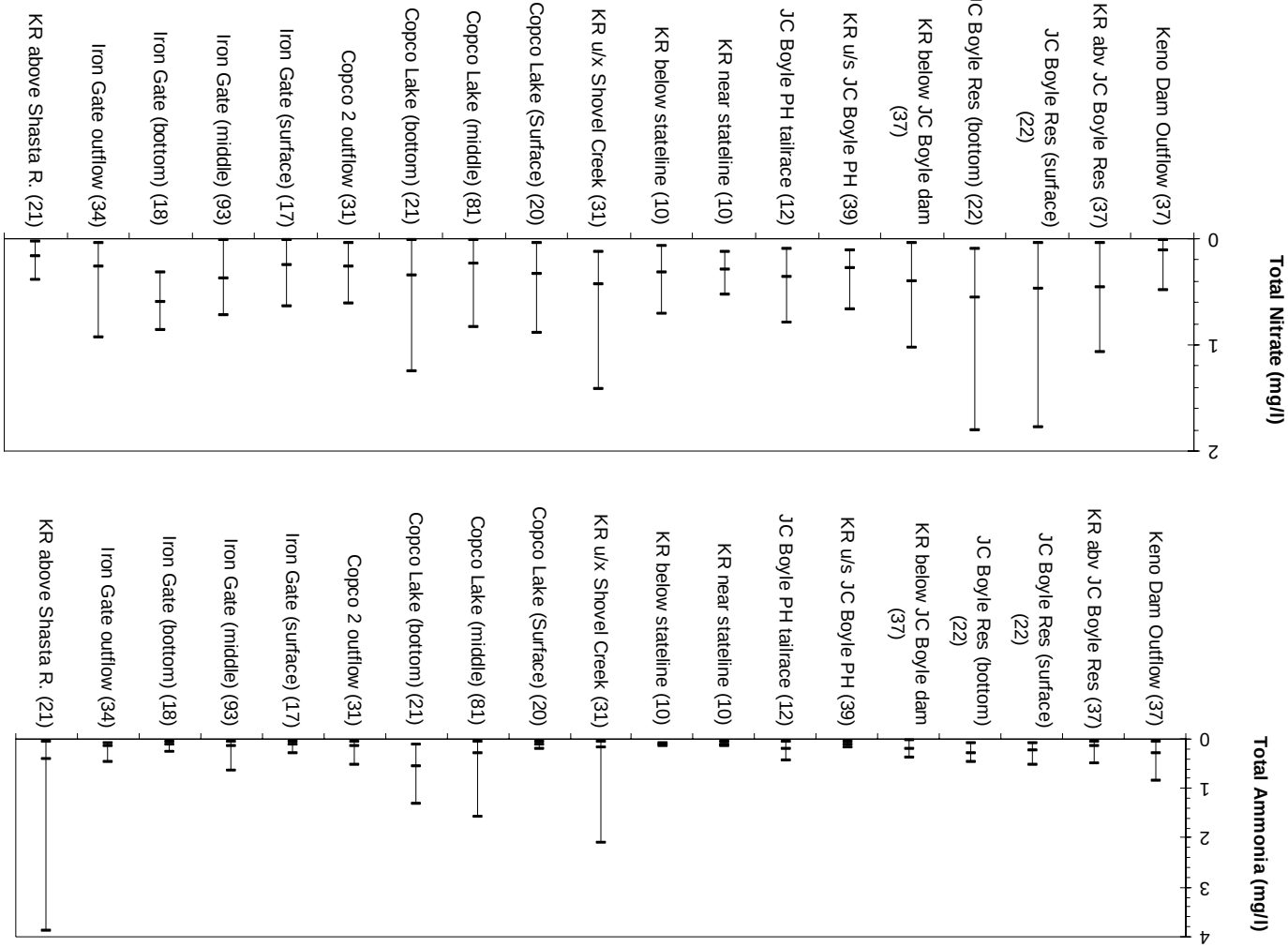
Note: Sample sizes are given in parentheses.

Figure 3-42. Minimum, mean, and maximum total phosphorous (top) and orthophosphate (bottom) concentrations (mg/L) in the Klamath River from Keno dam to the confluence with the Shasta River during June, July, August, and September 2001-2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)



Note: Sample sizes are given in parentheses.

Figure 3-43. Minimum, mean, and maximum total nitrate (top) and ammonia (bottom) nitrogen (mg/L) concentrations in the Klamath River between Upper Klamath Lake and Keno dam during June, July, August, and September 2001–2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)



Note: Sample sizes are given in parentheses.

Figure 3-44. Minimum, mean, and maximum total nitrate (top) and ammonia (bottom) nitrogen (mg/L) concentrations in the Klamath River between Keno dam and the confluence with the Shasta River during June, July, August, and September 2001-2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)

Both Copco and Iron Gate reservoirs nutrient sampling results exhibit the characteristics of productive, stratified lakes. PacifiCorp's data show that Copco reservoir has a much higher annual concentration of ammonia, orthophosphate, total phosphorus, and nitrate in the hypolimnion than in the epilimnion (see figures 3-42 through 3-44). Concentrations of these constituents are at their greatest during the summer months as the reservoir thermally stratifies (table 3-30). PacifiCorp's total phosphorus sampling data from Copco reservoir indicates that the mean values from the hypolimnion are greatest in August and September (0.5 and 0.7 mg/L, respectively); however, by November, when the water column is isothermal, the concentration drops to 0.1 throughout the entire water column. In Iron Gate reservoir, total phosphorous concentrations are the same in both epilimnion and hypolimnion, or even lower in the hypolimnion than the epilimnion and at concentrations well below those seen in Copco reservoir in the summer (figure 3-42, top).

Table 3-30. Mean total phosphate, orthophosphate, and ammonia (mg/L) in Copco and Iron Gate reservoirs in samples collected between 2001 and 2004. (Source: PacifiCorp, 2004a and 2005n, as modified by staff)

Station	June	July	August	September	October	November
Total Phosphorous (the number in parenthesis is the number of samples)						
Copco (top 8 m)	0.2 (3)	0.2 (4)	0.2 (2)	0.3 (4)	0.2 (1)	0.1 (1)
Copco (9-19 m)	0.1 (11)	0.3 (11)	0.3 (11)	0.3 (12)	0.3 (11)	0.0 (11)
Copco (20-32 m)	0.3 (2)	0.3 (4)	0.4 (3)	0.7 (5)	0.6 (1)	0.2 (1)
Iron Gate (top 9 m)	0.2 (3)	0.1 (5)	0.2 (2)	0.2 (4)	0.2 (1)	0.2 (1)
Iron Gate (9-19 m)	0.1 (13)	0.1 (14)	0.1 (14)	0.2 (15)	0.1 (11)	0.1 (13)
Iron Gate (20-45 m)	0.2 (2)	0.1 (5)	0.1 (2)	0.2 (5)	0.2 (1)	0.2 (1)
Orthophosphate						
Copco (top 8 m)	0.1 (3)	0.1 (4)	0.2 (2)	0.2 (4)	0.2 (1)	0.1 (1)
Copco (9-19 m)	0.1 (11)	0.2 (11)	0.3 (11)	0.3 (12)	0.3 (11)	0.0 (11)
Copco (20-32 m)	0.3 (2)	0.3 (4)	0.3 (3)	0.6 (5)	0.6 (1)	0.1 (1)
Iron Gate (top 9 m)	0.1 (3)	0.1 (5)	0.1 (2)	0.2 (4)	0.1 (1)	0.2 (1)
Iron Gate (9-19 m)	0.1 (13)	0.1 (14)	0.1 (14)	0.2 (15)	0.1 (11)	0.1 (13)
Iron Gate (20-45 m)	0.1 (2)	0.1 (5)	0.1 (2)	0.1 (5)	0.2 (1)	0.2 (1)
Ammonia						
Copco (top 8 m)	0.1 (3)	0.1 (4)	0.1 (2)	0.1 (4)	0.1 (1)	0.2 (1)
Copco (9-19 m)	0.1 (11)	0.1 (11)	0.3 (11)	0.6 (12)	0.6 (11)	0.1 (11)
Copco (20-32 m)	0.4 (2)	0.4 (4)	0.7 (3)	0.9 (5)	1.0 (1)	0.2 (1)
Iron Gate (top 9 m)	0.1 (2)	0.1 (3)	0.2 (2)	0.1 (3)	0.1 (1)	0.2 (1)
Iron Gate (9-19 m)	0.1 (12)	0.0 (14)	0.1 (13)	0.2 (14)	0.3 (11)	0.2 (13)
Iron Gate (20-45 m)	0.1 (1)	0.1 (4)	0.1 (1)	0.1 (4)	0.2 (1)	0.2 (1)

The amount of oxygen present in the water also affects nutrient chemistry. Extended periods of hypoxia or anoxia (low or zero oxygen) promote conditions that result in the reduction of nitrate to ammonia and can lower the oxidation-reduction potential (redox potential – a measure of the electrical potential of ions in the water) 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 (PacifiCorp, 2004a). The differences in redox potential in the reservoirs are reflected in nutrient concentrations in the hypolimnion. Orthophosphate and ammonia are noticeably more abundant in the hypolimnion of Copco reservoir than in Iron Gate reservoir (figures 3-42 and 3-44 and table 3-30).

Seasonal changes in water quality constituents below Iron Gate dam are presented in table 3-31, below. Orthophosphate and total phosphorous concentrations are highest in March with little variability throughout the rest of the year and little difference between the two sampling locations. Ammonia

concentrations remain fairly constant throughout the year, with occasional high values in May, September, and October. Notably, ammonia values near Shasta River are considerably higher in October compared to concentrations measured below Iron Gate dam. Nitrate tends to increase slightly in the fall at both sampling locations.

Table 3-31. Water quality constituents at sites sampled downstream from Iron Gate dam. (Source: PacifiCorp, 2004a and 2005n; as modified by staff)

Month (sample size range)	Iron Gate dam outflow, mean 2000-2004 (mg/L)				Above Shasta River, mean of 2002 and 2004 data (mg/L)			
	TP	PO_4	NH_3	NO_3	TP	PO_4	NH_3	NO_3
March (0-1)	0.38	0.36	0.07	0.23				
April (0-2)	0.16	0.08	0.05	0.34				
May (3-6)	0.14	0.10	0.13	0.15	0.09	0.06	0.16	0.09
June (3-7)	0.17	0.15	0.10	0.18	0.13	0.09	0.06	0.02
July (3-7)	0.17	0.13	0.11	0.23	0.15	0.13	0.04	0.06
August (3-7)	0.14	0.14	0.08	0.16	0.15	0.15	0.10	0.09
Sept (3-7)	0.19	0.14	0.14	0.44	0.14	0.11	0.15	0.21
Oct (3-6)	0.13	0.12	0.14	0.38	0.12	0.12	1.99	0.24
Nov (3-5)	0.10	0.10	0.2	0.4	0.12	0.10	0.07	0.36

The ratio of total nitrogen to total phosphorus in the Klamath River system is below 7 (median = 6.6). 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) generally indicates phosphorus limitation. The median N:P ratio in the project area equals 6.6:1, and only about 20 percent of all values are greater than 10:1. This condition holds from Link River 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.*

Sediment Oxygen Demand

PacifiCorp commissioned a sediment oxygen demand (SOD) study to analyze sediment core samples from Keno, J.C. Boyle, Copco, and Iron Gate reservoirs in 2003. More recently, Eilers and Raymond (2005) performed a similar study in Lost River and Keno reservoir to enhance current TMDL model development. USGS also commissioned SOD sampling in Keno reservoir in 2003.

PacifiCorp's study showed that SOD in project reservoirs ranged from 1.5 to 4.7 $g/m^2/day$. SOD in reservoirs above J.C. Boyle dam was all above 2.0 $g/m^2/day$, while SOD in Copco and Iron Gate reservoir was between 1.0 and 2.0 $g/m^2/day$. Results from Eilers and Raymond (2005) are consistent with PacifiCorp's work where SOD in the Lost River and Lake Ewauna ranged from 1.32 to 3.61 $g/m^2/day$. The results indicate that the oxygen dynamics of the upper study area, especially at 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, and such effects may play a larger role in water quality dynamics in the hypolimnion in Copco and Iron Gate reservoirs.

SOD rates measured by USGS in June 2003 (USGS, 2003) at 16 sites in Keno reservoir and published as provisional results ranged from 0.6 to 3.11 (median of 2.15) $g/m^2/day$. Results from the Eilers and Raymond 2005 study are consistent with results of the earlier Eilers and Gubala study and USGS (2003). PacifiCorp concludes that, although sediments exert an oxygen demand, the SOD in the water column is less than the biological demand in Keno and J.C. Boyle reservoirs.

Water enters Keno reservoir with a substantial biological oxygen demand (BOD) present, presumably derived from decomposition of the entrained cyanobacteria (Eilers and Gubala, 2003, as cited in PacifiCorp, 2004f). Eilers and Gubala (2003, as cited in PacifiCorp, 2004f) conclude that BOD in the waters of the Lake Ewauna (upper) portion of Keno reservoir overshadows the effects of the sediment in the lower portion of Keno reservoir and J.C. Boyle reservoir to a considerable degree. In Copco and Iron Gate reservoirs, BOD is lower and sediment effects become a more important influence on the quality of the overlying water (Eilers and Gubala, 2003, as cited in PacifiCorp, 2004f).

Algae

Algae within the Klamath River are an important component to the overall water quality and water chemistry processes affecting water quality within the system. The seasonal blooms and die offs of algae in response to conditions within the water at various locations throughout Upper Klamath Lake and the project waters have consequences throughout the entire system. In Upper Klamath Lake, algae productivity is associated with DO that shows extreme daily variation (high during the day and low at night) and elevated pH and free ammonia concentrations that do not meet Oregon's water quality standards (Kann and Walker, 2001; Walker, 2001), and chlorophyll *a* concentrations (a surrogate measure of planktonic algae abundance) exceeding 200 µl/L are frequently observed during the summer months[58] (Kann and Walker, 2001). Carlson Trophic State Index (TSI)[59] values calculated from PacifiCorp monitoring data (based on chlorophyll *a* concentrations) for Upper Klamath Lake at the Freemont St. Bridge range from 55 in May to 77 in June.

As expected, chlorophyll *a* concentrations are higher in the reservoirs than the river sections directly upstream except for Link River. The average chlorophyll *a* concentration entering Keno reservoir from Link River is 57 µg/L with a peak concentration of 257 µg/L in July. Peak algal abundance (chlorophyll *a* concentrations near 300 µg/L) in Keno reservoir occurs in June. TSI index values based on monthly chlorophyll *a* in Keno in July, August, and September ranged from 64 to 70.

Water entering J.C. Boyle reservoir has an average chlorophyll *a* concentration of 14.5 µg/L with a peak concentration of 58 µg/l. Chlorophyll *a* concentrations steadily decrease downstream of the J.C. Boyle powerhouse. The average and peak chlorophyll *a* concentration in the peaking reach is 7.8 µg/L and 23 µg/L, respectively. Sampling results near the Copco and Iron Gate dams show that both reservoirs are highly productive. The average and peak chlorophyll *a* values at Copco reservoir were 10.7 µg/L and 44 µg/L, respectively, and at Iron Gate reservoir, 10.3 µg/L and 58.0 µg/L, respectively. The chlorophyll *a* concentrations in both reservoirs varies seasonally (figure 3-45). Generally, monthly Carlson TSI values for chlorophyll *a* decrease from upstream to downstream in Keno, J.C. Boyle, and Copco reservoirs with all values in Copco in the 40 to 50 range. TSI values in Iron Gate are slightly higher than those calculated for Copco, but within the same range. There is a predictable sequence of algal taxa in both reservoirs. During March there is typically a bloom of diatoms, followed by a period of relatively low chlorophyll abundance. Chlorophyll usually peaks in August and September when dense blooms of the nitrogen-fixing cyanophyte (blue-green alga) *Aphanizomenon flos-aquae* occur.

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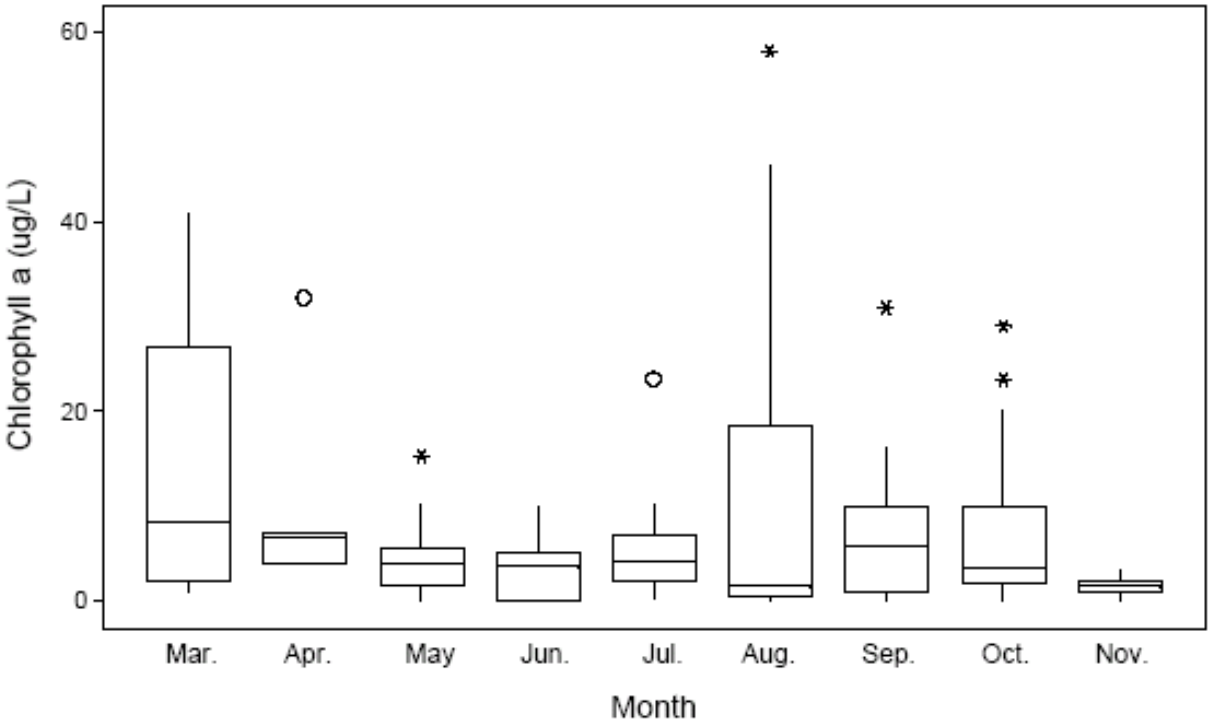
[58]The Organization for Economic Cooperation and Development has established lake classifications for various levels of biological productivity. Lakes with a mean of 25 ug/L or a peak concentration of 75 µl/L of chlorophyll *a* respectively are considered hypereutrophic (Phillip Williams and Associates, 2001). Wetzel (2001) defines freshwater lakes with concentrations of chlorophyll *a* greater than 10 µg/L as eutrophic.

[59]Carlson TSI is a generally accepted index of trophic status of lakes based on the relationship of the seasonal means of Secchi disk, chlorophyll *a*, and total phosphorus. Generally, the "greener" the lake, the higher the TSI number, and the lower the water visibility. Conditions are considered eutrophic when TSI values are between 51 and 70, and hypereutrophic when values are above 70.



Notes: The limits of the box enclose the central 50 percent of the distribution. The horizontal line in the middle of the box represents the median value. 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)

Figure 3-45. Box plot showing the distribution by month of combined chlorophyll *a* values measured in Copco and Iron Gate reservoirs during 2000 to 2003. (Source: PacifiCorp, 2004a)

Chlorophyll *a* data filed as part of PacifiCorp's historical water quality database (part of the final license application) includes chlorophyll *a* values below Iron Gate dam. Figure 3-46 shows the monthly values for sites below Iron Gate dam available in the database. Chlorophyll *a* concentrations experience the greatest range and highest average at the station closest to Iron Gate dam. Downstream of the RM 182.38 sampling point, the mean remains relatively even while the range in reported values increases with distance downstream. Figure 3-47 shows the seasonal trends in average chlorophyll *a* concentrations in the Klamath River below Iron Gate dam. Chlorophyll *a* concentrations are relatively equal at all sites in April and increase noticeably at the station above Cottonwood Creek than the stations lower on the Klamath in June and August and drop to similar concentrations at all stations monitored in October.

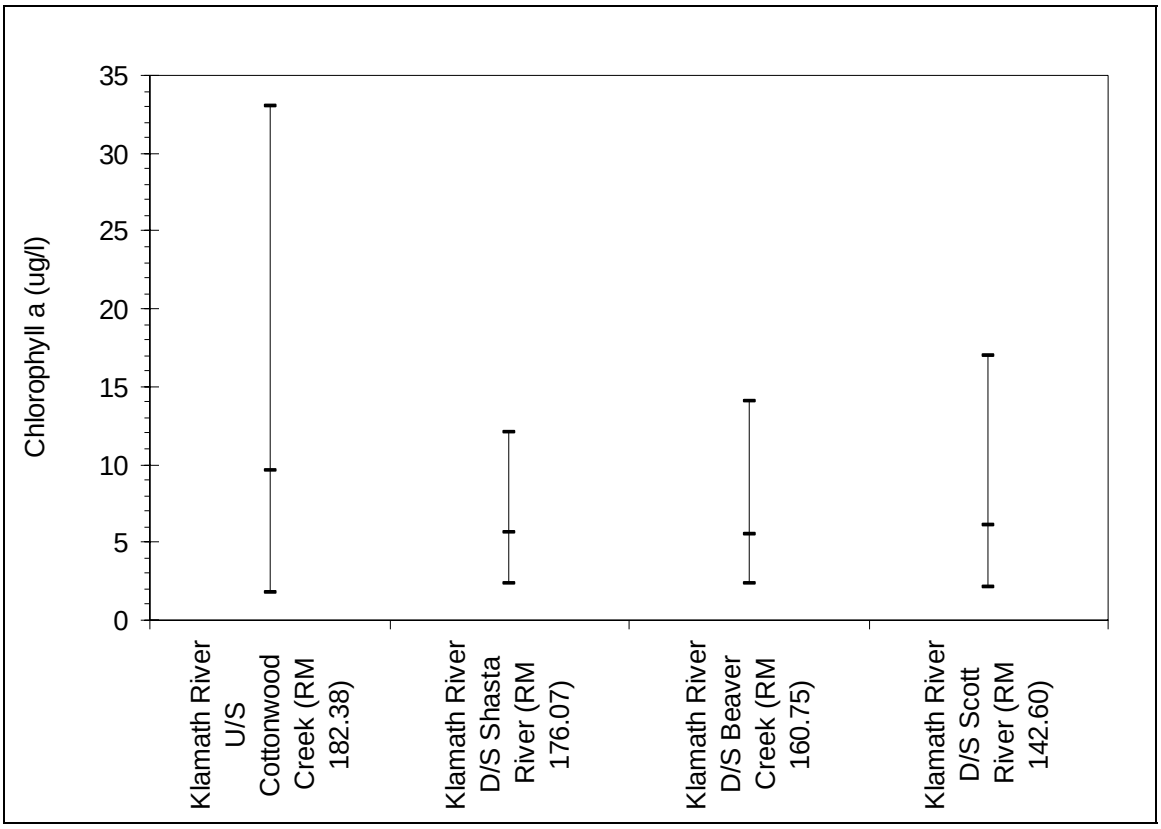


Figure 3-46. Maximum, mean, and minimum chlorophyll *a* concentrations at four stations below Iron Gate dam from data collected in 1996 and 1997. (Source: PacifiCorp, 2004a, as modified by staff)

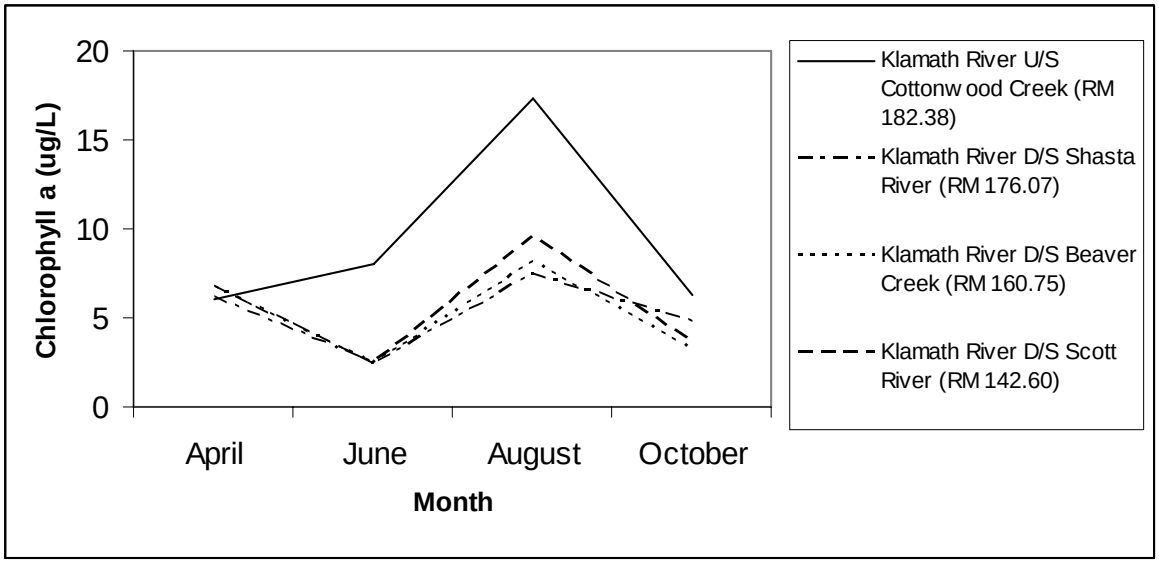


Figure 3-47. Seasonal trends in chlorophyll *a* concentrations at four stations below Iron Gate dam from data collected in 1996 and 1997 by NCRWQCB. (Source: Tetra Tech 2004a, as modified by staff)

The blue-green algae (cyanobacteria) species, *Microcystis aeruginosa*, which produces the potent liver toxin, microcystin, has been observed historically in Upper Klamath Lake (Environmental Health Perspectives, 1999) and throughout the Klamath River Basin. The species has been documented within and downstream of Copco and Iron Gate reservoirs in each year since 2002 (Kann and Corum, 2006; PacifiCorp, 2007c). *Microcystis* densities as high as 1.9 million/cells/mL and microcystin concentrations as high as 482μ/L were reported in Copco reservoir in 2004 (Kann and Corum, 2006).

Cell densities of *Microcystis aeruginosa* exceeded the World Health Organization's moderate risk levels[60] at all sampled stations on August 10 and 11, 2005, including at the open-water stations in front of Iron Gate (916,548 cells/mL) and Copco (151,004 cells/mL) dams. Results from the 2005 sampling program issued by Kann and Corum (2006) show that *Microcystis aeruginosa* cell density exceeded the World Health Organization's Level for Moderate Probability of Adverse Health Effects by 10 to more than 100 times, and a 40 pound child accidentally ingesting 100 milliliters of reservoir water would have exceeded the World Health Organization's tolerable daily intake level by 10 to more than 100 times. As a result of the high July samples, the Water Board issued a public health advisory (Water Board and California EPA, 2005). The advisory stated that the concentrations of the *Microcystis aeruginosa* cyanobacteria levels and resulting microcystin toxin detected in samples collected from both shoreline and open water locations in Copco and Iron Gate reservoirs pose a significant potential threat of adverse health effects in human and animals exposed through direct ingestion of contaminated water as well as incidental ingestion during recreational water activities and bathing (designated beneficial uses of project waters). The Water Board (2006) issued a similar health advisory again in 2006, noting that *Microcystis* concentrations in the reservoirs were higher in 2006 than 2005.

PacifiCorp also performed phytoplankton sampling from 2001 to 2005 at 22 sites along the Klamath River in the vicinity of the Klamath Hydroelectric project including Upper Klamath Lake and its tributaries. Summary statistics show that the highest mean algal abundance (measured as over 7,500 units/ml), were observed in the Klamath River at the Keno Bridge (Highway 66), Link River, and Upper Klamath Lake (at Freemont St. Bridge) (Raymond, 2005). Results also show that the blue green algae *Microcystis aeruginosa* was found in about 12 percent of the 462 samples taken throughout the project vicinity; however, the spatial and temporal variability has not been disclosed at this time. According to Kann and Asarian (2006), the overall longitudinal trend for phytoplankton biovolume and important nitrogen-fixing and bloom forming species follow a declining trend from Upper Klamath Lake to above Copco reservoir, with a subsequent increase in the Copco and Iron Gate reservoirs. Kann (2006), investigating PacifiCorp's data, reported low incidence and magnitude of *Microcystis* leaving Upper Klamath Lake and in the Klamath River above Copco reservoir and high incidence and magnitude in Copco and Iron Gate reservoirs.

Attached algae and rooted vegetation within the Klamath River also play an important role in nutrient dynamics, as well as general river ecology. Because attached algae are in continuous contact with the river, the growth and distribution of the algal communities can affect nutrient fluxes and result in short-term changes in water quality parameters such as dissolved oxygen and pH. The Upper Klamath Lake TMDL recognized that aquatic plants are abundant in portions of the upper Klamath River and in areas dominated by nuisance filamentous green algae species such as *Cladophora,* an algae common in nutrient enriched waters. Field work contracted by EPA sampled 10 sites in the Klamath River below Iron Gate dam to characterize the benthic algae (periphyton) community. Follow-up sampling was performed in 2004 under a collaborative effort that included PacifiCorp, the Water Board, and the Yurok Tribe. Attached algae was sampled from Klamath River and tributary sites between Iron Gate dam and Weitchpec. Results suggest that there are major changes in the periphyton community that appear to be

[60]The World Health Organization states that, for recreational bathing waters, a moderate risk level is 50 μg/L chlorophyll *a*, 100,000 cells/mL or 20 μg/L microcystin in the top 4 meters of surface waters (California Department of Health Services, 2007).

controlled to some degree by differences in nutrient availability (Eilers, 2005) and that inter-annual biomass variability is likely substantial (Hoopa TEPA, 2006).

Species composition results showed a transition from a *Cocconeis/Diatoma*-dominated community upstream to a system heavily dominated by *Epithemia* downstream. *Cladophora* exhibited the greatest percentage of cover at the Shasta River sampling site where it represented one-half the periphyton community (by bio-volume). The study authors felt compelled to note that the biomass of periphyton was generally low to moderate, which was contrary to their expectations prior to the survey and reasoned that changes in the flow regime (possibly due to Reclamation orders) resulted in a doubling of flow from about 600 cfs around August 15 to about 1,200 cfs near the end of the month, settling at about 800 cfs by September 1, the start of the study. This increase in discharge may have been capable of dislodging filamentous algae that had proliferated under the previous lower flow regime (Eilers, 2005).

pH

The high concentration of algae in Upper Klamath Lake and Keno reservoir influences pH levels because photosynthesis and associated uptake of carbon dioxide results in high pH (basic conditions) during the day and respiration by algae and other organisms at night decreases the pH to more neutral conditions. Monthly average alkalinity (measured as $CaCO_3$) levels in Upper Klamath Lake, Link River, and Keno reservoir are fairly similar ranging between 40 and 50 mg/L with little variability throughout the sampling period. Values of 20 to 200 are typical of freshwater systems, however at lower levels freshwater systems have less buffering capacity, increasing their susceptibility to changes in pH. As expected, Link River water is more alkaline with strong seasonal trends. Concentrations ranged between 141 and 259 mg/L with the lowest levels recorded during the summer. PacifiCorp sampled pH as part of its water quality sampling program and collected almost 3,800 pH readings between March and November 2000 to 2004. Average pH values from all PacifiCorp sampling stations on the Klamath River and project reservoirs collected during the 2000 to 2003 study were between 7 and 10 standard units with the higher values coinciding with high algal densities, which typically occur from spring through fall.

Annual mean pH values show little variability between Keno reservoir and the bottom of the peaking reach. Water in Keno reservoir has an average pH of 8.2 with a peak pH of 9.4 standard units. Average pH in J.C. Boyle reservoir is 7.8 with a peak of 9.3 standard units. Downstream of J.C. Boyle development in the peaking reach (Klamath River just above Shovel Creek) the average pH was 8.1 with a peak of 8.9 standard units.

The pH of grab samples from Copco and Iron Gate reservoirs are similar to each other in that the average pH at the surface was 8.2 and 8.1, respectively, while below 20 meters the average pH was 7.3 in Copco and 7.2 in Iron Gate with very little difference during June through September (range in Copco epilimnion was 0.7 units and 0.5 in Iron Gate). The range in the hypolimnion of both Copco and Iron Gate reservoirs during the summer was 0.2, indicating that there is little variability in pH at depth within these reservoirs during the summer. Monthly average alkalinity levels within Copco and Iron Gate reservoirs are slightly higher than those recorded in Keno, however none are above 75 mg/L. Average pH values, based on hourly data, show a decreasing trend downstream of Iron Gate dam (figure 3-48). pH values are influenced by primary production and exhibit strong temporal changes, as shown in figure 3-49 for sites below Iron Gate dam and Seiad Valley.

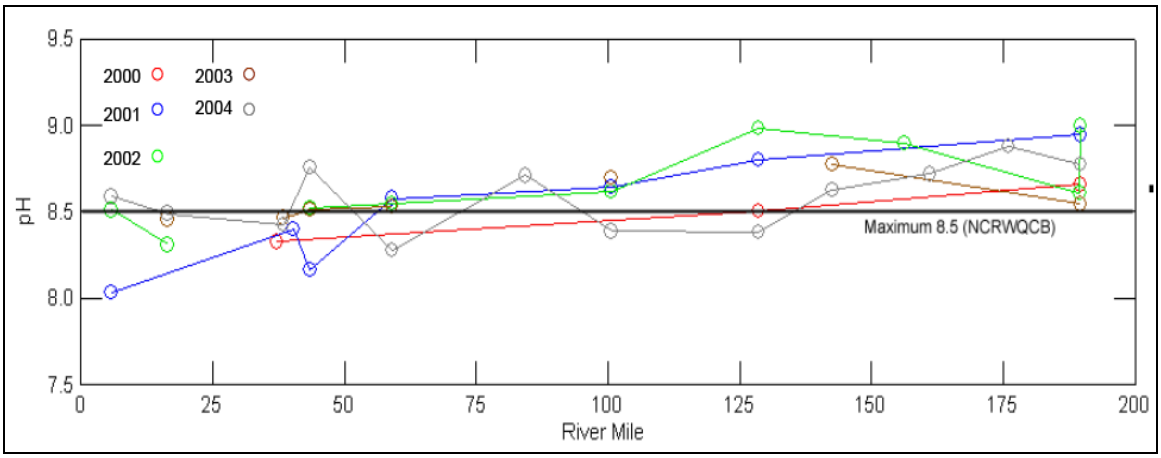


Figure 3-48. Average August daily maximum pH values for locations along the mainstem Klamath River below Iron Gate dam for the years 2000-2004 using data collected by FWS, USGS, and the Karuk and Yurok tribes. (Source: Kier Associates, 2006)

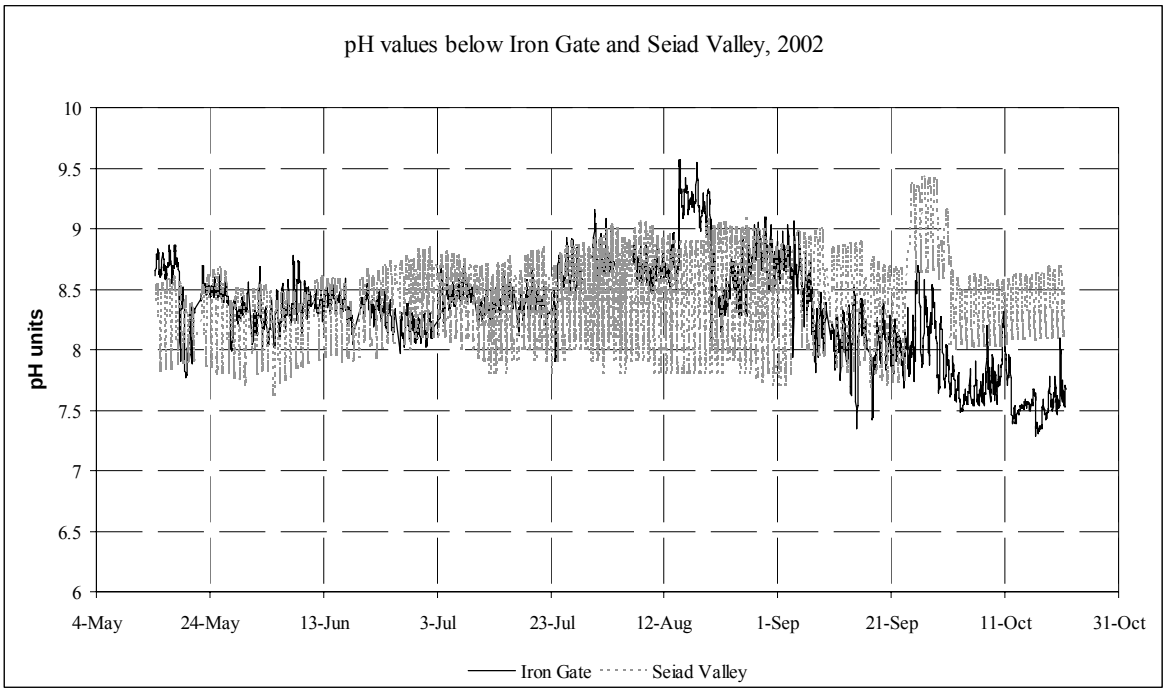


Figure 3-49. Variability in pH values in the mainstem Klamath River below Iron Gate dam and at Seiad Valley, 2002 (half hour intervals). (Source: Tetra Tech, 2004a, as modified by staff)

Water Clarity

Water clarity is a function of how much suspended material exists in the water and how far light can penetrate. The depth at which light extinction occurs in lakes and reservoirs can be easily measured by using a Secchi disk, which provides an indication of the depth at which the disk is no longer visible to the naked eye. The higher Secchi depth measurements mean greater water clarity. Table 3-32 shows

Secchi disk measurements at five representative locations within the project area (the mouth of Link River to Iron Gate reservoir). Water clarity is often predominantly influenced by planktonic algae, discussed earlier, and total suspended solids (TSS).

Table 3-32. Secchi depth[a] measurements at representative locations along the Klamath River in 2001 to 2003. (Source: PacifiCorp, 2004a)

Site Name	Number	Min.	Average	Max.
Link River Mouth (RM 253)	8	2.0	2.3	3.3
Keno Reservoir at Highway 66 Bridge (RM 234)	14	1.3	3.3	5.2
J.C. Boyle Reservoir (RM 224.8)	17	1.3	3.9	6.6
Copco Reservoir (RM 198.7)	25	0.6	6.2	11.2
Iron Gate Reservoir (RM 190.2)	25	3.0	7.5	13.8

[a] The average of the depths at which the Secchi disk disappears and the depth at which it reappears.

Measuring water clarity in river reaches requires a more complex sampling device designed to measure the water's turbidity, however, the instrument can be used in both lake and river conditions. A common unit of measure of turbidity is the nephelometric turbidity unit (NTU), which is a standardized measure of clarity based on light scattering in a water sample measured by the meter. The greater the amount of TSS in the water, the murkier it appears and the higher the measured turbidity.

Turbidity in project influenced reaches ranged from 0.9 to 184 NTUs (mean of the majority of the sites is below 10 NTUs) between 2002 and 2003 at many of the same locations as temperature and nutrient sampling; however, samples were not collected in the peaking reach. Table 3-33 shows the monthly mean turbidity values reported by PacifiCorp. The maximum reading of 184 NTUs was recorded in the epilimnion of Copco reservoir in May 2003.

TSS sampling results from 2003 (the only year sampled by PacifiCorp) indicate that TSS concentration ranged from 0 to 280 mg/L with the mean of Klamath River samples and reservoirs (including the metalimnion and hypolimnion of Copco and Iron Gate reservoir) of 7.9 mg/L. The maximum reading of 280 mg/L was recorded in the epilimnion of Copco reservoir in May, which corresponds to the same time frame when the maximum turbidity value was measured. The maximum TSS level recorded in the Copco outflow during the same month was 4.8 mg/L.

Toxics (Metals and Pesticides)

A concern about the potential toxicity of sediments behind the dams was addressed in a recent study sponsored by the California State Coastal Conservancy (GEC, 2006). Investigations were conducted into the volume, as well as physical and chemical characteristics of the sediment by collecting 27 sediment samples throughout J.C. Boyle, Copco, and Iron Gate reservoirs. The majority of samples were analyzed for volatile and semi-volatile organic compounds, metals, pesticides, and herbicides, while a select number of samples were analyzed for organophosphorus pesticides, nitrogen, phosphorus, cyanide, and dioxins. Of the 27 sediment samples analyzed, only one sample contained concentrations exceeding the Puget Sound Dredge Disposal Analysis screening criteria (Shannon & Wilson, 2006). The study found that no sediment samples contained metals, pesticides, herbicides, PCBs, DDT or dioxins at concentrations above screening levels. The only contaminants detected above screening levels were ethylbenzene and xylenes in one sample from Copco reservoir. The report describes these as common volatile organic compounds found in oils and gasoline, which likely come from recreational boats and would be expected to volatilize if resuspended. Shannon and Wilson (2006) theorize these compounds are present because they are bound to organics in the sediments.

Table 3-33. Mean turbidity (NTUs) in the Klamath River, 2002-2003. (Source: PacifiCorp, 2004a, as modified by staff)

Stations	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Link River[a]	10.1	8.5	8.1	12.9	11.0	11.0	12.0	11.8
Klamath Irrigation Project[b]		7.1	6.9	3.3	5.8	5.2	7.7	
Keno reservoir[c]	7.8	7.0	5.0	7.2	5.6	6.7	6.0	8.8
Klamath River below Keno dam	13.6	9.7	5.3	31.4	14.9	4.4	6.1	8.5
Klamath River above J.C. Boyle reservoir	13.4	9.5	6.0	7.3	11.9	3.4	4.9	8.4
J.C. Boyle reservoir at log boom (top 8 m)		8.9		6.5		2.8		
J.C. Boyle bypassed reach immediately below dam	14.4	10.0	6.0	7.6	4.8	2.9	3.1	7.8
J.C. Boyle bypassed reach (downstream end)	3.6	3.9	2.3	1.7	1.0	0.9	1.0	2.2
Klamath River above Shovel Creek (peaking reach)	11.4	7.5	4.8	6.8	2.1	2.0	3.1	3.8
Copco reservoir (top 8 m) near Copco		95.2		5.9		4.1		
Copco reservoir outflow	7.0	6.1	3.0	1.7	6.7	4.0	2.3	3.8
Iron Gate reservoir (top 9 m) near Hornbrook		7.1		2.1		2.3		
Iron Gate dam outflow	5.9	6.1	3.2	1.9	1.6	2.7	2.0	1.4

[a] Sampling points include: Link River near East Side powerhouse and Link River at mouth.

[b] Sampling points include: Lost River diversion canal at Klamath River, Klamath Straits drain pumping plant F, and Klamath Straits drain 200 feet downstream of pumping plant F.

[c] Sampling points include south-side bypass bridge, Miller Island boat ramp, upstream of Klamath Straits drain, between Klamath Straits drain and Keno dam, Keno Bridge (Highway 66), and Keno dam log boom.

PacifiCorp conducted a screening level assessment of chemical contaminants in fish tissue samples taken from Upper Klamath Lake, Keno, J.C. Boyle, Copco, and Iron Gate reservoirs to assess potential threats to humans from the bioaccumulation of toxic substances (PacifiCorp, 2004h). The Water Board (letter from R.J. Kanz to the Commission, dated April 22, 2004) considers the sampling a screening level analysis only, which provides direction on additional fish tissue and/or sediment sampling, yet to be determined. Screening level values (based on EPA criteria) for protection of human health used in the study are for recreational fishers and subsistence fishers. The results of the fish tissue analysis represent an indication of the degree to which toxics may be present in project-influenced water and sediment. However, because in some cases fish are known to migrate substantial distances, if contaminants are found in fish tissue, they may have originated from habitat outside the project area.

All measured fish tissue concentrations of total mercury are well below the screening values for human health. Total mercury concentrations (ppb dry weight) ranged from 0.154 to 2.527. The screening value for wildlife exposure used by PacifiCorp was 2.27 ppb, dry weight. Concentrations measured in largemouth bass from Iron Gate reservoir (two composite samples, 2.299 and 2.527 ppb) and Copco reservoir (a single composite totaling 2.438 ppb) are slightly above the screening value for wildlife exposure. All other measured mercury values were below the screening value for wildlife. PacifiCorp's screening level assessment collected two composite samples of six fish each of the target species from each reservoir (including Upper Klamath Lake for reference).

Although arsenic was detected in several samples, no concentration exceeded the method reporting limit[61] of 0.3 ppm. Estimated values (those values between the method reporting limit and the method detection limit [0.1 ppm]) for arsenic concentration in samples of largemouth bass from J.C. Boyle, Copco, and Iron Gate reservoirs are below the toxicity screening value for recreational fishers, but equal or exceed the toxicity screening value for subsistence fishers, a level of 0.147 ppm. Estimated arsenic concentrations exceeded the subsistence fishers' toxicity screening value in fish taken from J.C. Boyle (0.19 ppm), Copco (0.19 ppm) and Iron Gate (0.17 ppm) reservoirs. Cadmium and selenium values are below all screening values in all samples. No screening values were available for other metals.

DDE and hexachlorobenzene were the only two pesticides or pesticide byproducts detected in the study and were detected below the human health screening values. Some of the fish tissue samples from Upper Klamath Lake and Keno, J.C. Boyle, Copco, and Iron Gate reservoirs exceeded the suggested wildlife screening value for total DDTs, of which DDE is a component. Concentrations of DDE ranged from between the method detection limit of 0.56 ppb and the reporting limit of 2.0 ppb and a maximum of 2.91 ppb reported in J.C. Boyle fish. Hexachlorobenzene was detected in only two samples and at levels below the method reporting limit.

PCBs were detected in all samples from all of project reservoirs. Total PCB concentrations were less than the screening value for recreational fishers in all samples. Total PCB concentrations exceed the screening value for subsistence fishers in black bullhead from Keno reservoir, and in largemouth bass from J.C. Boyle, Iron Gate, and Copco reservoirs (table 3-34). Total PCB concentrations in all the samples analyzed were less than the toxicity screening value for protection of wildlife.

Table 3-34. Total PCBs found in composite fish tissue samples in Project reservoirs, 2003. (Source: PacifiCorp, 2004h)

Site	Species	Total PCB (ppb)
Upper Klamath Lake	Black Bullhead	0.846
Upper Klamath Lake	Black Bullhead	2.015
Keno Reservoir	Black Bullhead	2.926
J.C. Boyle	Largemouth Bass	0.885
J.C. Boyle	Largemouth Bass	1.397
J.C. Boyle	Largemouth Bass	3.521
Copco Reservoir	Largemouth Bass	2.822
Copco Reservoir	Largemouth Bass	2.158
Iron Gate Reservoir	Largemouth Bass	6.574
Iron Gate Reservoir	Largemouth Bass	4.909

Notes: Method Detection Limit: Varies
Method Reporting Limit: 0.200 ppb
Screening Values: Recreational fishers (0.2 ppb); Subsistence fishers (2.45 ppb); Wildlife (100 ppb).

Aesthetics

Recreational user surveys conducted by PacifiCorp in the project area in 2001 contained information from some respondents on the public's perception of water quality. Thirty-eight percent of respondents in the project area said that water quality had detracted from their visit. Table 3-35 summarizes their responses.

[61]The method detection limit is a statistically derived value, such that if an analyte is measured above this value the laboratory is 99 percent confident that the constituent is present at a value above this level. The method reporting limit is the limit at which the laboratory is confident about the measurement of the presence of the actual target analyte as determined within the sample matrix. Hence, values measured above the method detection limit but below the reporting detection limit are considered estimated values.

Table 3-35. Perceived effect of water quality on recreational visits in the Klamath Hydroelectric Project study area (yes/no). (Source: PacifiCorp, 2004c)

Survey Question: Has water quality ever affected your visit to the Klamath River area?

Resource Area	Yes (percent)	No (percent)
Link River/Lake Ewauna/Keno Reservoir	32	68
J.C. Boyle Reservoir	39	61
Upper Klamath River/Hell's Corner Reach	61	39
Copco Reservoir	35	65
Iron Gate Reservoir	32	68
Study Area (Total)	38	62

Of those persons who felt that water quality detracted from their visit, the most commonly cited factor was algae or aquatic plants (respondents mentioned "algae, green stuff, muck, seaweed, moss, slime") and the attendant odor. Other factors that were mentioned included dead fish and turbidity. We discuss project-related aesthetics in more detail in section 3.3.7.1.3, *Aesthetic Resources*.

3.3.2.2 Environmental Effects

3.3.2.2.1 Water Quantity

Flow and Water Level Monitoring

PacifiCorp's proposed flow and water level regimes for project-influenced reaches and reservoirs and the recommendations of other entities for flow and water level management cover a variety of alternative measures for each project development. Because measures related to flow and water level management primarily pertain to protecting and enhancing aquatic and riparian habitat and recreational opportunities, we discuss the specific aspects of these measures in sections 3.3.3.2, *Aquatic Resources*, 3.3.4.2, *Terrestrial Resources*, and 3.3.6.2, *Recreational Resources*.

Regardless of the flow and reservoir and river levels that may be specified in a new license, the Commission would require a means to ensure compliance with such license conditions. We discuss means for monitoring flow and water levels for compliance purposes in the following section. Flow and water level gages are in place on many project-affected reaches and reservoirs (table 3-36).

PacifiCorp did not include Keno development as part of its proposed project, citing its lack of influence on hydropower production. PacifiCorp would continue to own the dam and appurtenant facilities; however, it would relinquish all hydropower responsibilities associated with the current license and would operate the development according to direction from the state of Oregon and Reclamation. Future jurisdictional authority could affect environmental stewardship, which could affect the water levels within Keno reservoir and flow releases downstream. We cannot pre-judge the Commission's determination of whether Keno development should continue to be under its jurisdiction. Therefore, we discuss the management of the reservoir and its role in water quantity in the event that Keno development remains jurisdictional.

PacifiCorp proposes to install a stream gage in the J.C. Boyle bypassed reach to measure minimum flow and ramping rates immediately below the dam. PacifiCorp also proposes to install a Parshall flume at the Spring Creek diversion to measure the flows that are either routed to the diversion channel or to Spring Creek downstream of the diversion dam.

Table 3-36. Current gages in the vicinity of the Klamath Hydroelectric Project. (Source: PacifiCorp, 2004a; USGS, 2006a; Oregon Water Resources Department, 2006).

Gage Number	Location and or Name	Equipment Ownership	Responsible Party	Comments
11505800	Upper Klamath Lake at Rocky Point, OR	USGS and PacifiCorp	Reclamation and PacifiCorp	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
11505900	Upper Klamath Lake at Rattlesnake, OR	USGS and PacifiCorp	Reclamation and PacifiCorp	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
11507000	Upper Klamath Lake at Pelican, OR	USGS and PacifiCorp	Reclamation and PacifiCorp	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
11507001	Upper Klamath Lake near Klamath Falls, OR	USGS and PacifiCorp	Reclamation and PacifiCorp	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
	West Side powerhouse	PacifiCorp	PacifiCorp	generation records by PacifiCorp
	East Side powerhouse	PacifiCorp	PacifiCorp	generation records by PacifiCorp
11507500	Link River at Klamath Falls, OR	USGS and PacifiCorp	USGS	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
	Keno reservoir, Weed Bridge, OR.	USGS and PacifiCorp	USGS	Records by PacifiCorp
	Keno reservoir at Keno dam, OR	PacifiCorp	PacifiCorp	Hourly readings recorded by PacifiCorp
11509500	Klamath River at Keno, OR (below Keno dam)	USGS and PacifiCorp	USGS	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
11510000	Spencer Creek	ORWD	ORWD	Active from Nov 2002 to Sep 30, 2003
	J.C. Boyle reservoir	PacifiCorp	PacifiCorp	Hourly readings recorded by PacifiCorp
	J.C. Boyle powerhouse	PacifiCorp	PacifiCorp	generation records by PacifiCorp
11510700	Gage below J.C. Boyle powerhouse	USGS and PacifiCorp	USGS	Real time at the USGS website: http://waterdata.usgs.gov/or/nwis/rt
11511400	Copco reservoir[a]	PacifiCorp	PacifiCorp	Hourly readings recorded by PacifiCorp
	Copco No. 1 powerhouse	PacifiCorp	PacifiCorp	generation records by PacifiCorp
	Copco No. 2 reservoir	PacifiCorp	PacifiCorp	Records by PacifiCorp
	Copco No. 2 powerhouse	PacifiCorp	PacifiCorp	generation records kept by PacifiCorp
11512000	Fall Creek at Copco, CA	USGS	USGS	reactivated from May 2003 until September 2005
11516510	Iron Gate reservoir[a]	PacifiCorp	PacifiCorp	hourly readings recorded by PacifiCorp
11516530	Klamath River below Iron Gate dam, CA	USGS and PacifiCorp	USGS	Real time at the USGS website: http://waterdata.usgs.gov/ca/nwis/rt

[a] Daily readings provided to USGS. Daily data for the A canal, Lost River diversion channel, North canal, Klamath Straits drain and Ady canal are available from the Reclamation website at: http://www.usbr.gov/mp/kbao/operations/water/index.html.

Oregon Fish & Wildlife recommends that PacifiCorp provide for the installation of gages above all project reservoirs or diversions and outflow below each project dam at the head of the dewatered reach to provide compliance points for minimum flows and ramping rates. The gages would measure the full range of stage and flows that may occur at each site and include telemetry to record and transmit hourly streamflow data to the project control room, in accordance with applicable USGS standards. Oregon Fish & Wildlife's recommendation would involve the installation of the following new stream gages:

- One gage in the bypassed reach below Link River dam to ensure that East Side and West Side developments are only operated when flows from Link River dam exceed 500 cfs if these developments are not decommissioned.
- One gage in the bypassed reach below J.C. Boyle dam.
- One gage on Shovel Creek to quantify the amount of flow from this tributary, which would be used to help determine inflow to Copco reservoir and the amount of flow to be released to the Copco No. 2 bypassed reach.
- Two gages upstream and downstream of the diversion on Spring Creek to determine flow diversion compliance.
- Two gages at Fall Creek, one upstream of the power canal diversion to determine the inflow for minimum flows within the bypassed reach and another within the bypassed reach to determine minimum flow compliance.

The Oregon Water Resources Department recommends that PacifiCorp fund the operation of USGS gage no. 11509500, Klamath River at Keno, Oregon, so that flows into J.C. Boyle reservoir can be monitored. NMFS recommends that PacifiCorp install gages where needed to appropriately monitor flow and reservoir elevation at each facility. Cal Fish & Game recommends that PacifiCorp measure and record inflow above all project reservoirs and outflow below each project dam. Gages would be installed where needed to appropriately monitor inflow and outflow from each facility. Flow records would be made available to resource agencies upon request.

The Bureau of Land Management specifies that PacifiCorp install or maintain continuously measurement stream gages at the following four locations:

- below Keno dam at existing USGS gage no. 11509500;
- at Spencer Creek, currently Oregon Water Resources Department gage no. 11510000, Spencer Creek near Keno, Oregon;
- in the bypassed reach below J.C. Boyle dam; and
- in the J.C. Boyle peaking reach at existing USGS gage no. 11510700, Klamath River below J.C. Boyle powerhouse, Oregon.

PacifiCorp offers two alternatives to the Bureau of Land Management 4(e) condition. The first is to eliminate the condition, because PacifiCorp states that all aspects of flows in the river channel are not within the Bureau's jurisdiction. PacifiCorp's second alternative 4(e) condition is essentially the same as the Bureau's condition.

Our Analysis

Measuring Flows in Link River. Link River dam, owned by Reclamation, controls the water level of Upper Klamath Lake and is not within the existing or proposed project boundary. Its operation, including the gates at the dam, is therefore not within the Commission's jurisdiction. PacifiCorp proposes to decommission East Side and West Side developments. USGS gage no. 11507500 is located downstream of the discharge from East Side development, but is upstream of the discharge from West Side development. West Side development has a rated hydraulic capacity of 250 cfs and is normally either operated near its capacity or not operated. East Side development has a rated hydraulic capacity of 1,200 cfs and a minimum capacity of 200 cfs. As table 3-12 shows, flow at the existing gage no. 11507500 is often below the combined capacity of the powerhouses and the current minimum flow. Water levels and releases from Upper Klamath Lake are managed by Reclamation based on requirements of the FWS 2002 BiOp, and, due to the large storage volume and surface area, flows released by Link

River dam do not vary rapidly. One exception to the stable water level of Upper Klamath Lake is very rare high wind events that can change the water level of the lake at Link River dam and result in unexpected variations in the flow releases at Link River dam. Such variations, however, would have nothing to do with operations at either East Side or West Side developments.

PacifiCorp's operation of the two developments enables some degree of control over discharges from the dam because, if West Side development is not operating, the 250 cfs flow capacity could be passed over Link River dam or through East Side. Because East Side has some ability to adjust flows that pass through it (from 200 to 1,200 cfs), any downward adjustment of flow could result in an increase in flow released at Link River dam into the bypassed reach. The existing real-time gage with web-accessible half hour reporting intervals in the Link River below the discharge of the larger development, and the ability of PacifiCorp to monitor the flow through powerhouses, should be sufficient to monitor the flow regime that is controllable by PacifiCorp's project operations in Link River, without adding an additional gage upstream of East Side development.

Measuring Flows from Keno Development. USGS gage no. 11509500, which is located less than 1 mile below Keno dam, measures flow releases from Keno dam. Currently, equipment at this real-time gage, with half hour reporting of gage height and flow, is owned by USGS and PacifiCorp, and USGS is the responsible party for gage operation. The existing gage would be sufficient to measure any reasonable flow regime that may be included in a new license. However, some entities recommend that the flow regime in the Keno reach reflect a percentage of inflow. Inflow from Link River can be reasonably determined by the existing USGS gage. If such a provision is included in a new license, however, PacifiCorp would need to establish a means to obtain hourly inflow and outflow data from Reclamation's Klamath Irrigation Project, which both diverts and returns water to Keno reservoir (see table 3-15 and figure 3-7). The complexity of inflow and outflow from Keno reservoir would make measuring compliance with a flow regime tied to percentage of inflow to Keno reservoir exceedingly difficult.

The responsibility for continued operation of the USGS gage in the Keno reach would depend on the nature of the flow regime specified in a new license for Keno (if it remains within the Commission's jurisdiction) and J.C. Boyle developments. If Keno development is determined by the Commission to be non-jurisdictional, continued operation of this gage could be necessary if the flow regime for the J.C. Boyle bypassed or peaking reaches are calculated as a percentage of inflow to J.C. Boyle reservoir, as recommended by some entities. If the flow regime is not based on continuous monitoring of inflow to Boyle reservoir, there would be no nexus of the USGS gage at Keno to project purposes. If this gage does not serve project purposes, it would still serve an important non-project purpose, which would be to measure and document flows released by Reclamation in accordance with its BiOps.

Measuring Flows in Spencer Creek. With a drainage area of more than 35 square miles, Spencer Creek is the largest stream providing inflow to J.C. Boyle reservoir that is not measured at the USGS gage in the Keno reach. This gage has been active in the past, most recently from November 2002 until the end of September 2003, and was operated by the Oregon Water Resources Department. The need for this gage depends on the flow regime requirement downstream of J.C. Boyle dam (see discussion in section 3.3.3.2.1, *Instream Flows*). Reactivation and likely upgrades to allow for the continuous and real-time reading of this gage only would be required if the flow regime for the J.C. Boyle bypassed or peaking reaches is calculated as a percentage of inflow to J.C. Boyle reservoir. If the flow regime is not based on a percentage of inflow to J.C. Boyle reservoir, the Spencer Creek gage would serve no project purpose, and its operation would not be PacifiCorp's responsibility.

Measuring Flows in the J.C. Boyle Bypassed Reach. Flow compliance monitoring for any alteration of the existing flow regime in the J.C. Boyle bypassed reach would likely require a gage downstream of J.C. Boyle dam. The ideal location for a new gaging station would be below both the dam and the water conveyance structures such as the fish ladder and fish bypass outflow. Placing the new

gage upstream of the springs that add more than 200 cfs to the bypassed reach about 0.5 mile below the dam would ensure that compliance monitoring is not complicated by inflow not controlled by PacifiCorp. Access to the river channel to construct and maintain a gaging station is also more favorable upstream of the major spring inflow site. Depending on the substrate and stability of the channel in the limited length of the reach that appears to be generally suitable for a gage, it is possible that the construction of a weir would be needed to establish an accurate stage/discharge relationship. Such a weir could serve as a fish passage barrier at low flow levels, which would also need to be considered in the design of this gage site. Installation of a flow gaging station in the bypassed reach would result in environmental consequences associated with the construction of the gage station itself, the associated access road (if a new access road is needed), and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, destabilization of existing slopes, disturbance of aquatic and riparian habitat, potential degradation of the local visual quality, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details regarding how each of these effects would be addressed. Consultation with USGS for the development of this gage site would help ensure future compliance with USGS standards for flow measurement.

Measuring Flows in the J.C. Boyle Peaking Reach. Flow compliance monitoring for the flow regime that may be specified for the J.C. Boyle peaking reach would likely necessitate the continuing operation of gage no. 11510700 at RM 219.7 about 0.7 mile downstream of the J.C. Boyle powerhouse. Currently, equipment at this real-time gage, with half hour interval readings of gage height and flow accessible via the USGS website, is owned by USGS and PacifiCorp, and USGS is the responsible party for gage operation. This existing gage should be sufficient to measure flows in the J.C. Boyle peaking reach that are under PacifiCorp's control regardless of the flow regime specified in a new license.

Measuring Flows in Shovel Creek. Shovel Creek enters the J.C Boyle peaking reach about 3.5 miles upstream of Copco reservoir and contributes the largest single inflow to the J.C. Boyle peaking reach prior to its confluence with Copco reservoir. The need for this gage depends on the flow regime that is specified in a new license for the Copco No. 2 bypassed reach. Installation of this gage could be required if the flow regime is based on a percentage of inflow to Copco reservoir, as recommended by some entities, and if synthetic hydrograph relationships based on other nearby streams such as Fall Creek or Spencer Creek are not suitable. The ideal location of this gage, at least for access issues, would be near Ager-Beswick Road, which crosses over Shovel Creek just above the confluence with the Klamath River. Depending on the substrate and stability of the channel at accessible locations along Shovel Creek, a weir may need to be constructed to establish an accurate stage/discharge relationship. However, a weir could restrict or prevent upstream fish passage at low flow levels.

Shovel Creek is the primary rainbow trout spawning habitat along the peaking reach. Installation of a flow gaging station at Shovel Creek would result in environmental consequences associated with the construction of the gage station itself and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, disturbance of aquatic and sensitive riparian habitat along Shovel Creek, potential degradation of the local visual quality, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details on how each of these effects would be addressed. Consultation with USGS for the development of this gage site would help ensure future compliance with USGS standards for flow measurement. If the flow regime at the Copco No. 2 bypassed reach is not based on a percentage of inflow to Copco reservoir, the Shovel Creek gage would serve no project purpose, and its construction and operation would not be the responsibility of PacifiCorp.

Measuring Flows Downstream of Copco Nos. 1 and 2 Dams. Cal Fish & Game recommends that PacifiCorp measure and record outflow from all project dams. This would include outflow from Copco No. 1 dam. Flows from the Copco No. 1 powerhouse or spillage at Copco No. 1 dam discharge directly into Copco No. 2 reservoir, and no entity has made any flow recommendations that pertain to releases from the Copco No. 1 development. Therefore, the need to measure and record outflow from Copco No. 1 dam is not established.

Flow compliance monitoring for a new flow regime for the Copco No. 2 bypassed reach would likely necessitate a new gage downstream of Copco No. 2 dam. The ideal location for a flow gaging station would be downstream of the dam and any water conveyance structure, such as the proposed flume for providing minimum flows to the bypassed reach. Depending on the substrate and stability of the channel in the location, it is possible that the construction of a weir would be needed to establish an accurate stage/discharge relationship. A weir could restrict or prevent upstream fish passage at low flow levels, so a stable natural cross section location would be best. Installation of a flow gaging station in the Copco No. 2 bypassed reach would result in environmental consequences associated with the construction of the gage station itself, the associated access road, if needed, and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, disturbance of aquatic habitat, potential degradation of the local visual quality, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details regarding how each of these effects would be addressed. Consultation with USGS for the development of this gage site would help ensure future compliance with USGS standards for flow measurement, if appropriate.

Measuring Flows in Spring Creek. PacifiCorp maintains an earthen dam on Spring Creek, a tributary of Jenny Creek, which it uses to divert up to 16.5 cfs to Fall Creek and the Fall Creek powerhouse. Spring Creek has a relatively stable baseflow from groundwater accretion. Depending on the flow regime specified for Spring Creek in a new license, a gage could be required upstream of the diversion dam, downstream of the diversion dam, or in the diversion canal. Installation of one or two flow gaging stations, as several entities recommend (one upstream and one downstream of the diversion dam) would result in environmental consequences associated with the construction of the gage stations and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, disturbance of aquatic and riparian habitat, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details regarding how each of these effects would be addressed. Consultation with USGS for the development of this gage site (or sites, depending on the flow requirements of a new license) would help ensure future compliance with USGS standards for flow measurement.

A Parshall flume, proposed by PacifiCorp at this site to measure minimum flow downstream of the diversion dam, is one of the most widely used types of flumes for fixed flow monitoring. Depending on the flow regime requirements for the Spring Creek diversion dam, a Parshall flume could provide a lower maintenance and stable flow regime to Spring Creek downstream from the diversion than a USGS compatible gaging station.

Measuring Flows in Fall Creek. Fall Creek enters the upper part of Iron Gate reservoir. USGS gage no 11512000, downstream from the powerhouse, was in operation from April 1, 1933, to September 30, 1959, and recently from October 1, 2003, until September 30, 2005. Similar to Spring Creek, Fall Creek has a stable baseflow due to a large amount of groundwater accretion. Currently a flow of 0.5 cfs is provided via a notch in the stop logs at the diversion dam to the bypassed reach. A minimum flow of 15 cfs is provided downstream of the powerhouse through operation of the powerhouse, including a turbine bypass valve, and flow through the bypassed channel. Downstream of the powerhouse on Fall Creek there are flow intakes for the city of Yreka and for the currently inactive Fall Creek rearing facility. The need for one or two (as some entities have recommended) new gages at the Fall Creek diversion dam and or in the bypassed reach depends on the flow regime specified in a new license. Installation of one or two flow gaging stations (one upstream and one downstream of the diversion dam) would result in environmental consequences associated with the construction of the gage stations and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, disturbance of aquatic and riparian habitat, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details regarding how each of these effects would be addressed. Consultation with USGS for the development of this gage site (or sites, depending on the flow

requirements of a new license) would help ensure future compliance with USGS standards for flow measurement, if appropriate.

If the flow regime within the bypassed reach varies based on inflow, as some entities recommend, a gage upstream of the diversion dam would be needed. If flow released to the bypassed reach is required to vary seasonally, then a gage in the bypassed reach would likely be needed. If flow released to the bypassed reach is constant, similar to existing conditions, or with only a few yearly variations, then an orifice, weir, or Parshall flume could be suitable to maintain and document compliance with the flow regime. Installation of a fully automated flow gaging station at the diversion dam or especially in the bypassed reach would result in environmental consequences associated with the construction of the gage station itself and provision of electricity to operate the gaging station instrumentation (e.g., potential erosion and sedimentation, disturbance of aquatic habitat, and potential disturbance of cultural sites). Plans for a gaging station could provide site-specific details on how each of these effects would be addressed. Consultation with USGS for the development of these gage sites would help ensure future compliance with USGS standards for flow measurement, if appropriate. Construction of an orifice, weir, or Parshall flume at the diversion dam would have a more limited disturbance footprint, and any expected environmental effects associated with its construction likely would be minimal.

Measuring Flows Downstream of Iron Gate Dam. Flow compliance monitoring for releases from Iron Gate reservoir would necessitate the continuing operation of gage no. 11516530 at RM 189.5 about 0.5 mile downstream of the dam. This gage is a real-time gage with flows and gage heights available on the USGS website at 15 minute intervals. Currently, equipment at this gage is owned by USGS and PacifiCorp, and USGS is the responsible party for gage operation.

Monitoring Reservoir Water Levels. As part of the regular facility monitoring, PacifiCorp monitors the water level at Keno, J.C. Boyle, Copco, and Iron Gate reservoirs and reports daily values to USGS. This type of monitoring is needed for project operations. Because the reporting is done in accordance with USGS standards of hydrological accuracy, we see no reason to conclude that this would not continue for the developments that are included in the project during the term of the new license.

Plans for Water Level and Flow Monitoring and Project Operation

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp develop and submit to the Commission for approval, within 1 year of license issuance, a project operations resource management plan, in consultation with Oregon Fish & Wildlife and other state, federal, and tribal resource agencies. This plan would be updated every 5 years, in consultation with the agencies, to reflect new information and management needs and updated implementation strategies. An annual report would be submitted to the Commission and the agencies and would include the plan for the upcoming year and a compilation of monthly information and daily project inflow; graphical plots of hourly flow data below Link River, Keno, and J.C. Boyle dams and J.C. Boyle powerhouse; a graphical plot of hourly ramping rates; and a summary of non-compliance reports. Oregon Fish & Wildlife and the Hoopa Valley Tribe also recommend that PacifiCorp develop a coordinated gage installation and data reporting plan in consultation with appropriate agencies.

Reclamation specifies that PacifiCorp provide it with the area-capacity curves for all project facilities and real-time access to reservoir elevation and release data for project facilities. The Bureau of Land Management specifies that PacifiCorp, within 1 year of license issuance, provide instantaneous 30-minute real-time streamflow data via remote access in a format that is readily available and accessible to the public; and design and maintain a database, similar to the most current version of the USGS National Water Information System, for reporting on surface water. The Bureau of Land Management also states that, within 2 years of license issuance, PacifiCorp should begin submitting annual water year reports to the Bureau within 6 months of the end of each water year.

PacifiCorp's first alternative 4(e) conditions would be to eliminate Reclamation's and Bureau of Land Management's conditions pertaining to provision of project-related flow and reservoir water level information. PacifiCorp states that both conditions are beyond the authority of each land management agency. As a second alternative to the Bureau of Land Management's conditions, PacifiCorp would provide, within 1 year of license issuance, instantaneous real-time streamflow data (in cfs) at 30-minute intervals via remote access that is readily available and accessible to the public. It would maintain a database similar to the most current version of the USGS National Water Information System that stores gage network data and streamflow tracking procedures. PacifiCorp also would submit annual streamflow data reports to the Bureau of Land Management within 2 years of license issuance and within 6 months of the end of the water year. This second alternative condition is essentially the same as the Bureau of Land Management's condition.

Our Analysis

PacifiCorp already monitors, or in some case provides assistance to USGS for monitoring and recording, many hydrologic indicators, such as reservoir water levels and stream gage sites in the project area (see table 3-36). Daily and, in many cases, hourly or shorter interval data recording allows PacifiCorp to manage its facilities for hydroelectric generation and document environmental compliance with the terms of its existing license. The configuration of future flow and water level monitoring gages would depend on the operating conditions that may be specified in a new license. Flows that are provided to the Klamath Hydroelectric Project and released from Iron Gate development are based on conditions specified in BiOps that pertain to the operation of the Klamath Irrigation Project by Reclamation, as discussed in the following section. Developing a project operations management plan, as recommended by Oregon Fish & Wildlife and the Hoopa Valley Tribe, would provide an effective forum to establish the basis for reporting flow-related information to resource and land management agencies that have a need for this information, as well as for Commission staff to document compliance with conditions that may be specified in a new license for this project. Developing a coordinated gage installation plan, in consultation with resource and land management agencies, as well as USGS, would ensure that any new gages necessary to measure the flows and water levels that may be specified in a new license would provide accurate data consistent with applicable USGS standards. It also would enable the justification for the type of new gage (i.e., a gage with real-time, telemetry capabilities, or a gage without such capabilities) that is installed at each site to be documented, and any needed modifications to existing flow gages (either USGS or PacifiCorp) identified. However, it is unclear why a separate project operations management plan and gage installation plan would be needed, because both plans would be designed to establish the means to effectively monitor and report project-related flows and water surface elevations that may be specified in a new license. Consolidating the plans into a single project operations coordination and monitoring plan would be an efficient approach to addressing issues related to documenting and reporting project-related flows. Many project-related flows would depend on flows released from the Klamath Irrigation Project that are subject to the provisions of annual operations plans and conditions of Reclamation's BiOps. In addition, the adaptive nature of many flow-related measures, discussed in detail in sections 3.3.3.2, *Aquatic Resources*, and 3.3.4.2, *Terrestrial Resources*, may result in future changes in project operations. Consequently, including provisions to periodically update a project operations coordination and monitoring plan appears to be warranted. The 5-year interval for such updates recommended by Oregon Fish & Wildlife and the Hoopa Valley Tribe seems reasonable.

Reclamation specifies that PacifiCorp provide it with area capacity curves for all project developments. However, PacifiCorp already provided the area capacity curves for each reservoir in exhibit B of its license application (the license application is available on the Commission's website). It is also unclear why Reclamation would need real-time access to all project reservoir water elevations and flows released from each project development. Such information could be needed if it pertains to operations of the Klamath Irrigation Project, as would be the case if Keno development is determined by the Commission to be jurisdictional, or if it pertains to documentation of flows specified in Reclamation's

BiOps, as would be the case for flows released from the Iron Gate development. As table 3-36 shows, real-time flow information is already available from the USGS gage downstream of Iron Gate dam. However, by including Reclamation among the consulted parties during the development of a project operations coordination and monitoring plan, Reclamation could make its case as to why it should be afforded access to real-time project-related water level and flow information that is not also available to the general public. We consider the Bureau of Land Management's measure to provide real-time streamflow data in a format readily accessible to the public to be primarily related to establishing when riverine recreational opportunities exist at the J.C. Boyle bypassed and peaking reaches, and we discuss this measure in section 3.3.6.2.2, *River Recreation*. The remainder of the Bureau of Land Management's measure pertains to establishing the format and frequency of reporting flow and water level data to the Bureau and other entities. As previously discussed, such details would be appropriately addressed during the development of a project operations coordination and monitoring plan.

Coordination of Project Operations with those of the Klamath Irrigation Project

Flow reaching PacifiCorp's facilities largely depends on releases from Upper Klamath Lake and from withdrawals and return flows from the Klamath Irrigation Project. Upper Klamath Lake provides about 83 percent of the total water storage of the reservoirs along the mainstem of the Klamath River, and about 97 percent of active storage. Reclamation's 2002 BiOps (FWS, 2002a; NMFS, 2002) require water level management in Upper Klamath Lake to protect the federally listed Lost River and shortnose suckers and seasonal specified minimum flows from Iron Gate dam to protect the federally listed coho salmon in the Klamath River downstream of the project. Operation of Keno reservoir helps to manage the irrigation withdrawals and return flows from the Klamath Irrigation Project.

Until April 2006, PacifiCorp operated and maintained Link River dam under a contract with Reclamation. This contract provided PacifiCorp with some operational flexibility with respect to releases from Link River dam, in exchange for operating the dam and providing low-cost power to Reclamation and its Klamath Irrigation Project irrigators. PacifiCorp continues to operate Link River dam under an annual contract, renewable at the parties' discretion. PacifiCorp currently operates Keno dam under an agreement with Reclamation which was required by article 55 of the existing license. A stable water level in Keno reservoir facilitates consistent water delivery to dependent water users, including about 41 percent of the lands irrigated by the Klamath Irrigation Project and the Lower Klamath Lake National Wildlife Refuge (see figure 3-6). There are also a large number of privately owned diversions from Keno reservoir for irrigation of non-federal lands.

Reclamation specifies that PacifiCorp continue to operate and maintain Link River dam in a manner consistent with the Klamath Irrigation Project annual project operation plans and develop, in consultation with Reclamation, operational criteria for the coordination of Link River and Iron Gate dam to allow Reclamation to meet its responsibilities. Reclamation similarly specifies that PacifiCorp in consultation with Reclamation develop operational criteria that provide for the coordination of Keno and Iron Gate dams to allow Reclamation to meet its responsibilities. In addition, Reclamation specifies that PacifiCorp, at its own expense, maintain the approach channel to Reclamation's A canal to allow it to carry at least 1,200 cfs when Upper Klamath Lake is at elevation 4,137 feet. The justification for this condition hinges on PacifiCorp's continued operation of Link River dam, which Reclamation states "…must ensure that the primary diversion facility for the Klamath Reclamation Project is not affected by PacifiCorp's operation for power generation." Reclamation specifies that nothing in the new contract that it specifies should be developed between Reclamation and PacifiCorp for operation and maintenance of Link River and Keno dams should curtail the rights of Reclamation to Klamath water or lands along Upper Klamath Lake and that no water should be used by PacifiCorp if it is needed by Reclamation or by any other party that obtains water from the United States for use for domestic, municipal, and irrigation purposes on "project land (we assume this relates to Klamath Irrigation Project lands)." Reclamation also specifies that PacifiCorp should operate Keno dam so the water level does not fall below elevation

4,085.0 feet, as measured at or near the present location of the Highway 66 Bridge at Keno, and that PacifiCorp operate Keno dam to accommodate a discharge of 3,000 cfs from the Lost River diversion channel and 600 cfs from the Klamath Straits drain.

Our Analysis

Under a contract that expired in April 2006, PacifiCorp operated and maintained Link River dam at Reclamation's direction. As discussed in section 2.1.1.1, *East Side and West Side Developments*, in April 2006 the Commission issued its order setting the government dam use charges at the rates established in its regulations. Link River dam is not within the current project boundary and would not be within any new project boundary. Consequently, direct operation of the dam is not within the Commission's jurisdiction. Reclamation, as the owner of Link River dam, would be free to arrange for operation and maintenance of this dam with a qualified entity, and it is logical to assume that such operational responsibilities would include ensuring that the operations are consistent with the annual project operations plans and Reclamation's BiOp responsibilities. PacifiCorp's operation of East Side and West Side developments, over which the Commission has jurisdiction, has the potential to influence flows in Link River, but any such influence would be eliminated with the decommissioning of both developments, as PacifiCorp proposes. Reclamation's A canal approach channel is located about 0.3 mile above Link River dam, and the water levels of Upper Klamath Lake are specified in Reclamation's BiOp that is protective of federally listed suckers (FWS, 2002a). Based on available information, we have been unable to establish a nexus of maintaining the approach channel to Reclamation's A canal to any Klamath Hydroelectric Project purpose.

PacifiCorp already closely coordinates its operation of Keno and other facilities with Reclamation due to the interconnectivity between the Klamath Hydroelectric Project and the Klamath Irrigation Project. PacifiCorp is currently required by the Commission, under a 1965 license amendment, to operate Keno reservoir in accordance with an agreement with Reclamation that specifies that the maximum water surface elevation should be 4,086.5 feet and the minimum should be 4,085.0 feet. However, at the request of irrigators, PacifiCorp generally operates Keno dam to maintain the reservoir at elevation 4,085.4 +/-0.1 foot from October 1 to May 15 and elevation 4,085.5 +/-0.1 foot from May 16 to September 30 (see figure 3-8) to allow reliable operation of irrigation canals and pumps. Occasional 2-foot drawdowns are implemented following coordination with Reclamation to allow irrigators to clean out their water withdrawal systems before the irrigation season. If Keno dam remains within the project, we expect this operation regime to continue as it has since at least 1990 (see figure 3-8), with the water level of Keno reservoir generally remaining above elevation 4,085.0 feet. Provisions for documenting compliance with this minimum water level, which is necessary for gravity fed irrigation channels that divert water from Keno reservoir, would be appropriately addressed in a project operations coordination and monitoring plan, discussed previously. However, there are circumstances (such as an extreme flood event), that could prevent any entity that is operating Keno dam from ensuring that a discharge of 3,000 cfs from the Lost River diversion channel and 600 cfs from the Klamath Straits dam could be accommodated while maintaining Keno reservoir within a specified operating band. These types of exceptions (i.e., to accommodate routine maintenance of withdrawal systems of irrigators and other consumptive water users at Keno reservoir and extreme natural flow events) emphasize the importance of establishing a project operations coordination plan to ensure that operation of Keno development, if it remains under the Commission's jurisdiction, is consistent with the resource needs of those parties affected by its operation.

However, should the Commission determine that Keno development is not jurisdictional, PacifiCorp would still need to coordinate with Reclamation to ensure that flows released from Iron Gate development are consistent with Reclamation's BiOp for the protection of coho salmon (NMFS, 2002). Including Reclamation among the consulted entities during the development of a project operations coordination and monitoring plan would ensure that Reclamation's BiOp responsibilities are met by

PacifiCorp's operation of the Klamath Hydroelectric Project, regardless of which specific developments are included in a new license for the project.

Oregon law, as interpreted by the Oregon Water Resources Department, determines water rights related to withdrawals from Upper Klamath Lake or Keno reservoir. Any water rights disputes that arise in Oregon between Reclamation and PacifiCorp would be for that department to resolve. The Commission would not attempt to resolve any issues regarding whether Klamath River water should be used for consumptive purposes by clients of the Klamath Irrigation Project or for hydroelectric purposes, if such use would conflict with established consumptive purposes.

3.3.2.2.2 Water Quality

Keno Reservoir Water Quality Management

Currently, water quality within Keno reservoir does not meet state objectives and a TMDL for the Klamath River is currently underway to address elevated pH, ammonia, nutrients, temperatures, chlorophyll *a*, and low DO concentrations. PacifiCorp states that poor quality of inputs and not project operations are the cause of poor water quality throughout the project area. The combination of hypereutrophic water in Upper Klamath Lake, coupled with the extensive amount of irrigated lands supported by the Klamath River, supply (at times), nutrient enriched water to Keno reservoir. During summer, conditions in Keno reservoir are ideal for algal blooms; elevated water temperatures, ample sunlight, and elevated nutrient levels from the greater percentage of enriched flow from Klamath Straits drain. The resultant algal blooms exacerbate water quality problems by affecting pH and DO, and may potentially include blooms of *Microcystis aeruginosa*, which produce a toxin that can be a threat to human health (discussed later in this section). Isolating the nutrient loading and the effect of Keno reservoir on water quality from Upper Klamath Lake, non-point sources, and internal loading has yet to be performed; however, the TMDL analysis currently underway will identify these loads.

In its license application, PacifiCorp did not include Keno development as part of its proposed Klamath Hydroelectric Project, and it stated that it does not believe Keno dam is rightly under the Commission's jurisdiction, due to its lack of influence on hydropower production. PacifiCorp states that it would continue to own the dam and appurtenant facilities; however, it would relinquish all hydropower responsibilities associated with the current license and would operate the development according to state of Oregon and Reclamation direction. Future jurisdictional authority could affect environmental stewardship, which could affect the water quality within Keno reservoir and downstream. We cannot pre-judge the Commission's determination of whether Keno development should continue to be under its jurisdiction. Therefore, we discuss the management of the reservoir and its role in water quality in the event that Keno development remains jurisdictional and a part of the project.

NMFS recommends that within 1 year of license issuance, PacifiCorp develop, in consultation with the agencies, a plan to manage Keno reservoir to improve water quality for fish habitat and meet water quality standards as measured immediately downstream of Keno dam. NMFS indicates that possible measures that could be implemented under this plan include restoration of wetlands, treatment wetlands, mechanical aeration, and mechanical removal of algae. Should Reclamation develop such a plan that addresses water quality issues at Keno reservoir before, PacifiCorp would incorporate Reclamation's plan into its plan under NMFS' direction. FWS makes a similar recommendation to that of NMFS except as a precursor to the development of the plan, PacifiCorp would form and lead a regional team within 1 year of license issuance whose purpose would be to study and develop a Keno reservoir water quality plan. The plan would be filed with the Commission within 2 years of license issuance (rather than the 1 year specified by NMFS).

Oregon Water Resources recommends that PacifiCorp should be prepared to address Keno dam's share of TMDL effects on temperature, algae, and DO levels in Keno reservoir and the Klamath River.

The Klamath Tribe recommends that PacifiCorp fund efforts to plan and implement measures to ameliorate water quality problems generated within Keno reservoir.

Our Analysis

There is no disputing that the quality of water entering, within, and leaving Keno reservoir is degraded. However, the degree to which the presence of Keno dam influences that water quality is not as clear. The dam and its impoundment affect water quality primarily by increasing surface area and hydraulic retention time. This increases water temperature and facilitates photosynthetic and microbial processes that can degrade water quality, by causing DO and pH fluctuations, and increases in concentrations of nitrogenous compounds, including ammonia and other nitrogen species. Because the rate of flow through the reservoir is largely a function of Reclamation's need to meet the 2002 BiOp flows below Iron Gate dam, it appears that water quality problems in Keno reservoir would be the same whether or not Keno dam remains part of the project. In that sense, it is the presence of the dam (and associated reservoir), rather than its specific use, that contributes to the observed water quality degradation.

Ongoing TMDL studies are designed to establish the appropriate load for various pollutants that the Klamath River can assimilate. If point sources of pollution are identified in the watershed that cause the allocated TMDL to be exceeded, corrective actions would be identified through the National Pollution Discharge Elimination System (NPDES) permit process. However, past precedent has not identified water that passes through a hydroelectric dam as representing a point source of pollution, and thus an NPDES permit is typically not required. In a proposed rule that would amend the Clean Water Act, issued on June 7, 2006, EPA seeks to clarify that water transfers are not subject to NPDES permit requirements because no addition of a pollutant occurs (Federal Register: June 7, 2006. Volume 71, Number 109, pages 32,887 to 32,895). The proposed rule specifically states that "the movement of water through a dam is not water transfer because the dam merely conveys water from one location to another within the same waterbody." EPA notes in its proposed rule that pollutants in transferred water would best be addressed at the source by the states through such mechanisms as water resource planning, land use regulations, and conditions of a water quality certification.

We agree with EPA that an effective approach to addressing water quality issues for water passing through hydroelectric dams is through water resource planning. Such planning is already occurring in the project area through the TMDL process and the ongoing development of Reclamation's Conservation Implementation Program for the Klamath Irrigation Project (the most recent version of the plan was issued in February 2006). If Keno development is determined to be jurisdictional, it would be appropriate for PacifiCorp to participate in cooperative water resource planning with the relevant agencies to identify feasible means for improving the quality of water released from Keno dam. We consider measures to reduce nutrient loading in Keno reservoir and in downstream project waters to be the most likely remedial measure that would come out of such cooperative planning. If nutrients are reduced, algal production would decrease and the resultant DO regime would be enhanced. By assessing feasible methods of reducing nutrient loading from Keno dam to downstream project waters, it may be possible to curtail project-related effects at Copco and Iron Gate reservoirs. However, because the water quality at Keno reservoir influences water quality at all downstream project developments, development of a water quality management plan that encompasses all project waters, not just Keno reservoir, should be considered when specific remedial measures are developed. Consultation with appropriate resource agencies during the development of such a project-wide plan would ensure that water quality enhancement measures implemented by PacifiCorp would be developed with input from technical experts within resource agencies and coordinated with measures implemented by other parties pursuant to parallel water quality management initiatives. We discuss this approach later in this section under *Project-wide Water Quality Management*.

Water Temperature Remediation

Project operations have the potential to alter the temperature regime of affected waters. Keno and J.C. Boyle reservoirs generally do not stratify during the warmer months of the year (as indicated in section 3.3.2.1.2), and water entering and leaving the reservoir are approximately the same temperature. Lacking a hypolimnion, there are no controllable actions that can be taken to cool water released from either Keno or J.C. Boyle developments. Because Copco and Iron Gate reservoirs thermally stratify during the warmer months of the year (see figure 3-24), the potential exists that structural or operational changes at these projects could be used to reduce the temperature of water released downstream.

Figure 3-50 shows simulated water temperatures downstream of Iron Gate dam with and without the project, illustrating the effects of project operations on the downstream temperature regime. In general, the "without project scenario" has warmer temperatures in the spring and cooler temperatures in the summer and fall than the existing condition. This reflects the slower warming and slower cooling associated with the large water mass contained within the reservoir. Temperatures during much of July and August are usually higher than 20^0C with little variability. Figure 3-50 is based on 2002 data and represents a dry year resulting in more extreme summer temperatures. Modeling results for other years between 2000 and 2004 can be found in PacifiCorp's response to AIR AR-2 filed by letter dated October 14, 2005, which exhibit similar, albeit less extreme, temperature trends. As discussed in section 3.3.2.1, PacifiCorp regularly recorded average daily water temperatures below Iron Gate dam of more than 20°C in June, July, and August between 2000 and 2004. In this section, we discuss the effects of various operational procedures, potential structural modifications, and monitoring. We discuss the relationship between temperatures and aquatic resource needs in section 3.3.3.2, *Aquatic Resources*.

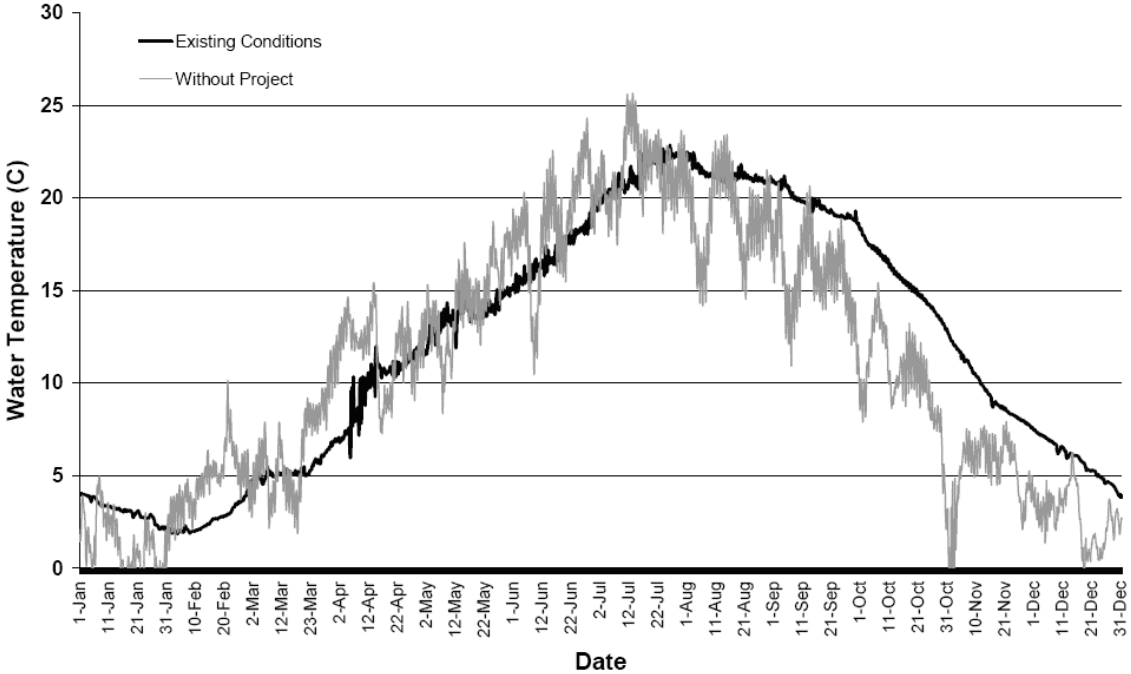


Figure 3-50. Simulated hourly water temperature below Iron Gate dam (RM 190.5) based on 2002 (considered a dry year) for existing conditions compared to hypothetical conditions without the existing Klamath Hydroelectric Project. (Source: PacifiCorp, response to AIR-AR-2, dated October 2005)

In its license application, PacifiCorp originally proposed to evaluate the feasibility and effectiveness of a low-level release of cooler hypolimnetic water from Iron Gate and Copco reservoirs during the summer to provide some cooling downstream of the project. We asked PacifiCorp to conduct this analysis in our AIR dated February 17, 2005 (AR-1). In its response, filed by letter dated August 1, 2005, PacifiCorp indicated that none of the preliminary facility or operational modifications they considered would result in any substantial relief to the warm summer and fall temperatures downstream of Iron Gate dam.

The Forest Service recommends that the temperature of water released from Copco and Iron Gate dams should be managed to compensate for project cooling effects in spring and warming effects in late summer and early fall. Studies to determine a preferred design of intake structures and an outflow schedule would be conducted, and an effective combination of structure(s) and release operations should be required that would result in the greatest change in degree-days.

NMFS recommends that within 1 year of license issuance, PacifiCorp file a temperature control device feasibility and implementation plan developed in consultation with the resource agencies. Feasibility would be conducted by an independent third party approved by the agencies to determine the potential effectiveness of a temperature control device at Copco No. 1 and Iron Gate dams to improve habitat resources for anadromous salmonids downstream of Iron Gate dam. The goal of the plan would be the development and implementation of a comprehensive management plan to improve water temperature conditions downstream of Copco No. 1 and Iron Gate dams. Methods and results would be reviewed by the agencies, and if the results of the feasibility study are favorable, PacifiCorp would implement the recommended temperature control measures. The plan would fully model, compare, and evaluate a variety of technologies, including but not limited to construction and operation of a multi-port selective withdrawal structure. It would also include an assessment of effectiveness, cost, and potential effects. FWS makes a similar recommendation; however, it also recommends that the study would include an uncertainty analysis to quantify model performance for all years simulated, establish a realistic target water temperature schedule, and assess effects of temperature control options on Iron Gate Hatchery operations.

Siskiyou County recommends "…appropriate terms and conditions that result in the aeration and management of cold water in the project reservoirs if these practices have appropriate benefits." Conservation Groups recommend that PacifiCorp operate the project in a run-of-river mode such that the amount of water entering an impoundment is equal to the sum of water passed over the dam, through fish passage facilities, and through the turbines at any given point in time at every relevant facility structure to enhance water temperature. Conservation Groups also recommend that PacifiCorp install adequate temperature monitoring devices and develop an effectiveness monitoring plan that includes the Klamath River downstream of Iron Gate dam to the confluence of the Shasta River to track compliance with water temperature objectives and force adjustments if temperature targets are not met. Conservation Groups also recommend that in the absence of project decommissioning, PacifiCorp should pass sufficient water through the J.C. Boyle and Copco No. 2 bypassed reaches to minimize thermal effects from warming throughout each reach.

Our Analysis

We have seen no evidence that operation of the project in a run-of-river mode as recommended by the Conservation Groups would result in downstream temperatures being more suitable for salmonids. Operating J.C. Boyle in a run-of-river mode is not likely to induce measurable differences in temperature in the peaking reach because of the relatively small volume of the reservoir and lack of substantial stratification. Operating Copco No. 1 and No. 2, and Iron Gate developments in a run-of-river mode would result in the continuous seasonal release of relatively warm epilimnetic water from Copco and Iron Gate reservoirs, resulting in little expected change from the existing temperature regime.

The Conservation Group's desire to minimize thermal effects from warming in the J.C. Boyle bypassed reach would best be achieved by releasing no flow to the bypassed reach, not more flow. The more than 200 cfs of springwater accretion in the bypassed reach ensures optimal thermal conditions for salmonids during the warm months of the year and any additional flow released from the dam would serve to further warm the bypassed reach water. We consider it inappropriate to manage the J.C. Boyle bypassed reach solely to reduce water temperature. As discussed in section 3.3.3.2.1, *Instream Flows*, both temperature and physical habitat (depth, velocity, and substrate) should be assessed when determining an appropriate flow regime for any stream reach.

Similarly, passing an alternative water flow through the Copco No. 2 bypassed reach, as recommended by the Conservation Groups, would likely have little effect on thermal regime. The bypassed reach is relatively short and much of it is shaded by encroaching riparian vegetation which, given the relatively low volume of flow currently passing through the reach (about 10 cfs), likely maintains water temperatures. Releasing additional flow from Copco No. 2 dam would pass warm water (originating from the epilimnion of Copco reservoir and passing through Copco No. 1 powerhouse) to the bypassed reach, most likely resulting in little change to current conditions. As indicated in the following paragraph, releasing cooler hypolimnetic water through a valve or gate at the base of the dam, may be possible, but such water would also be low in DO (see figure 3-35). Striking a balance between cooler temperature and DO that is likely to be acceptable for salmonids and resident fish in the bypassed reach would be difficult. Temperature, DO, and physical habitat should be considered collectively and this should be used to select an appropriate flow regime for the Copco No. 2 bypassed reach (see section 3.3.3.2.1, *Instream Flows*).

PacifiCorp modeling (response to AIR AR-2, October 17, 2005) of existing conditions compared to the without project scenario indicates that the project can have a noticeable effect on temperatures as far downstream as the confluence of the Scott River, 47 miles downstream of Iron Gate dam. The magnitude, downstream extent, and duration of project effect on temperatures is variable and influenced by numerous factors such as, but not limited to, water year type, climatic and meteorological conditions, and season. Differences in temperature between the modeled existing condition and the without project scenario are most noticeable during the summer and early fall months as the thermal mass of the reservoirs alter the downstream temperature regime. Modeling results indicate that effects of the project on temperature are difficult to discern by the confluence with the Salmon River, about 124 miles downstream of Iron Gate dam, which indicates that the likely downstream limit of project effects on water temperature is between the confluence of the Scott and Salmon rivers.

Thermal stratification and the associated cool water in the hypolimnion during warmer times of the year in Copco and Iron Gate reservoir provide the potential to allow selective withdrawals of water from depths within the reservoir to provide relief from peak summer temperatures downstream of Iron Gate. PacifiCorp analyzed the hypothetical release of hypolimnetic water from both Copco and Iron Gate reservoirs using the CE-QUAL-W2 modeling system which has since been incorporated by the EPA into their technical analysis of the forthcoming Klamath River TMDL, giving the model a high level of credibility for predicting flow and temperature. PacifiCorp estimates the maximum useable cold water volume in Copco reservoir to be about 3,100 acre-feet and 4,800 acre-feet at less than 14°C and 16°C, respectively. This maximum volume of cold water typically occurs around September 1, which is when it would most likely be needed to provide downstream temperature relief for migrating salmon. PacifiCorp's modeling results show that the duration of hypolimnetic releases from that storage would last about 1.8 days at 1,000 cfs. It may be possible to extend this release period by a small amount by reducing the release volume to less than 1,000 cfs. However, if inflow to Copco reservoir exceeds the amount released from near the base of Copco No. 1 dam, the reservoir would fill and spill, or epilimnetic water would need to be released through the powerhouse; both actions would release warm water into Copco No. 2 reservoir and negate the temperature benefits of the cool, hypolimnetic releases. As table 3-20 shows, the average flow at the Copco No. 1 powerhouse is 702 cfs in July, 804 cfs in August, and 974

cfs in September, which are the months when temperature relief would most likely to be needed. We independently reviewed PacifiCorp's area-capacity curves and vertical temperature profiles for Copco reservoir and concur with PacifiCorp's assessment of the relatively limited coldwater release capabilities at Copco No. 1 dam. To achieve releases of the magnitude and duration specified by PacifiCorp, releases would need to be made from a valve or gate near the base of the dam and water used in any such releases could not be used to generate electricity. PacifiCorp refurbished these low level outlets in 2005 to comply with state of California dam safety requirements (PacifiCorp, 2005i). As we note in the previous paragraph, any such hypolimnetic flow release would likely be very low in DO.

PacifiCorp's modeling indicates that at Iron Gate reservoir, the maximum volume of cold water (8°C or less) during the summer is about 8,000 to 10,000 acre-feet. If all of this cold water were passed through a point near the base of them dam at a release rate of 1,000 cfs, this cold water pool would last about 5 days. Our independent review of PacifiCorp's area-capacity curves and vertical temperature profiles for Iron Gate reservoir confirms PacifiCorp's assessment of the size of the cold water pool. We also estimate the approximate volume of the cold water pool available at Iron Gate reservoir in the hypolimnion that would be at or 15°C, to be about 20,000 acre-feet. A release of about 1,000 cfs from near the base of the dam could be sustained for about 10 days. PacifiCorp refurbished these low level outlets in 2005 to comply with state of California dam safety requirements (PacifiCorp, 2005i). As with hypolimnetic releases at Copco dam, the DO of water released from near the bottom of Iron Gate reservoir would generally be very low.

PacifiCorp's modeling efforts of selective withdrawal alternatives for Copco and Iron Gate show the cold water pool within the reservoirs could be used for modifying temperatures below the dam; however effects would be short term and would not affect the entire length of river below Iron Gate dam to the ocean. Our review of PacifiCorp's modeling efforts leads us to conclude that it is a valid tool to help understand the limitations of releases of cold, hypolimnetic water from Copco and Iron Gate reservoirs in relation to the temperature regime of project waters. If releases from Iron Gate dam are managed to sustain decreased temperatures for the longest duration, hourly temperatures would be reduced by about 1.1°C on average, with a maximum decrease of 1.8°C, for a period of up to 1 -1/2 months in late summer and early fall. Modeling of selective withdrawals from Iron Gate alone designed to maximize the decrease in downstream water temperatures showed promise but the benefits end within 2 weeks, as the cold water pool is depleted. Temperature benefits are reduced at Seiad Valley, with almost no benefit below Clear Creek (about 90 miles below Iron Gate) leaving the lower 100 miles of river unaffected. PacifiCorp's modeling results show that selective withdrawals could reduce temperatures below existing conditions by a maximum reduction of 10°C, which would last for about a day midway through the withdrawal period. As the distance downstream from Iron Gate dam increases, observed and modeled temperatures show greater variability as the river becomes more responsive to changes in meteorological conditions. The magnitude of the benefit is related to the hydrological conditions, as temperatures during drier years with less tributary inflow are more sensitive to releases from Iron Gate dam because they make up a greater percentage of the flow, whereas during wet years the opposite would be true. Selective withdrawal modeling scenarios designed to prolong greater temperature differences by incorporating Copco reservoir into a coordinated effort to lower water temperature downstream of Iron Gate dam showed negligible benefits.

Sustained temperature relief of more than 2 weeks to the Klamath River via releases from Iron Gate dam is not feasible. However the cold water pool in Iron Gate has some potential to cool downstream temperatures on a short term basis, and could be considered for extreme circumstances should environmental conditions trigger such a need (e.g., when large numbers of juvenile salmonids are present in the river under extreme temperature stress). Depletion of the cold water pool to reduce warm temperatures below Iron Gate dam would also likely decrease the DO concentration downstream of Iron Gate dam, through the release of oxygen depleted water from the hypolimnion, as previously noted. In addition, the sole water supply for Iron Gate Hatchery withdraws cold water from the deeper water of Iron

Gate reservoir, and depleting or exhausting this cold water pool during the summer would likely seriously impair hatchery operations during any year that such hypolimnetic releases occur (see section 3.3.3.2.6, *Iron Gate Hatchery Operations*). Development of a temperature control plan would provide the framework necessary to address cold water withdrawals while integrating water quality monitoring and aquatic resource needs. Addressing the feasibility of renovating the existing Iron Gate dam diversion tunnel to make controlled hypolimnetic releases or installing alternative hypolimnetic release valves or gates that could be activated in emergency circumstances to provide short-term downstream temperature relief could be included in a temperature control plan. In addition, conducting a feasibility study to assess alternative or supplemental Iron Gate Hatchery water supply options that could provide temporary cool water supplies to the hatchery (during any use of hypolimnetic water under emergency circumstances) would provide a basis to determine the overall feasibility of an emergency coolwater flow augmentation program. Alternative supply options to be studied could include: groundwater source availability, piping water from coldwater tributaries, or a combination of several options. NMFS and FWS recommendations for additional, third party, selective withdrawal modeling for the purposes of comparing and evaluating a variety of technologies would be unnecessary based on the limited amount of cold water storage available within Iron Gate reservoir and the current capability to release available cold water, if needed, at Iron Gate dam. An emergency water release plan that specifies environmental target temperatures by season and environmental triggers could be used to signal the release of cool water from storage in Iron Gate reservoir to provide short term benefits to anadromous fish experiencing temperature stress and may improve relief through critical early fall temperature extremes.

Operational measures reduce thermal lag and increase the rate at which outflows in the project warm in the early spring, including spills from Iron Gate dam, could assist fall Chinook salmon growth and early emigration (discussed in section 3.3.3.2.3, *Disease Management*). Initially this option could rely on existing facilities to achieve the benefits of limited short-term temperature relief. An adaptive management approach would allow the most flexibility in achieving temperature objectives while incorporating monitoring results to promote the appropriate conditions for aquatic resources. Details of such an approach could be specified in a temperature management plan.

Dissolved Oxygen Remediation

PacifiCorp's sampling and modeling efforts under "existing conditions" and "without project" scenarios show that operation of the project has an effect on the downstream DO regime. Specifically, the results show that project operations under existing conditions result in reduced DO releases, often below California's numerical objectives (listed previously in table 3-25), downstream of Iron Gate dam from late spring, through the summer and fall. The modeling results indicate that the project influences DO concentrations at least as far downstream as the confluence of the Klamath and Shasta rivers. Kier Associates (2006) states that daily average minimum DO concentrations in August 2004, show depressed concentrations below Iron Gate dam all the way down to the Scott River, with average daily minimum DO concentrations dipping below 6.0 mg/L.

Distinguishing project-related influences from non-project influences on the DO regime further downstream is difficult using either modeling or field measurements because of the number of variables that influence DO (e.g., degree of turbulence, time of year, time of day, influences of tributary inflow, and non-project-related BOD and SOD). Figure 3-51 shows DO concentrations below Iron Gate dam that are representative of dry, low flow conditions. Under the "without project" scenario, DO concentrations could drop below the state objectives of 8 mg/L; however, the duration of these conditions would be short lived compared to the modeled existing conditions. Modeling results for other years illustrate similar trends, with increased variability. These results can be found in PacifiCorp's response to AIR AR-2 dated October 17, 2005.

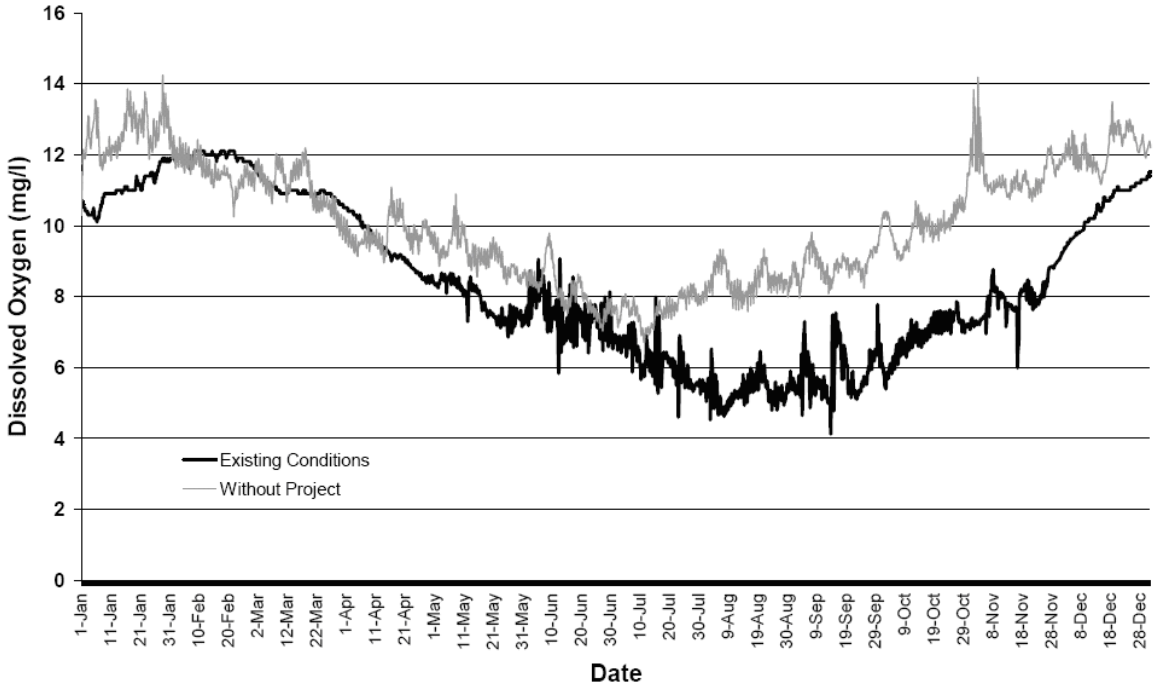


Figure 3-51. Simulated hourly DO levels below Iron Gate dam based on the year 2002 (a dry year) for existing conditions compared to hypothetical conditions without the Klamath Hydroelectric Project. (Source: PacifiCorp, response to AIR AR-2, dated October 17, 2005)

To address the reduced DO levels below Iron Gate dam, PacifiCorp proposes to install an oxygen diffuser system in Iron Gate reservoir to assist with compliance with the state water quality objective for DO downstream of the project (PacifiCorp, 2005, response to AIR AR-1 part [b]). The diffuser system would include a single diffuser line about 4,000 feet long, located in the deepest portion of the reservoir, designed to supply oxygen to the hypolimnion. The diffuser system would be operated seasonally each year beginning in the spring, as bottom water DO levels start to drop, and continue until reservoir turnover in the fall. Should conditions require, additional oxygen would be placed in the turbine water flow using three shorter diffusers in front of the intake tower. PacifiCorp proposes to monitor DO levels in the tailrace to provide guidance on potential adjustments of oxygen injection. As a separate, but related measure, PacifiCorp also proposes to develop and implement comprehensive water quality management plans for the reservoirs of the proposed project which would include an evaluation of the effectiveness and feasibility of several technologies, including further evaluation of hypolimnetic oxygenation and epilimnetic or surface aeration and circulation. We discuss PacifiCorp's proposed water quality management plans later in *Project-wide Water Quality Management*.

NMFS recommends that, within 1 year of license issuance, PacifiCorp file a DO enhancement plan, developed in consultation with the resource agencies, for the project reaches and Klamath River downstream of Iron Gate dam to improve habitat resources for anadromous salmonids. The goal of the plan would be the development and implementation of a comprehensive management plan to enhance DO downstream of Iron Gate dam that would include (1) measures to meet salmonid requirements for the geographic extent of the project DO effect; (2) further study of PacifiCorp's proposal to install a hypolimnetic oxygenation system in Iron Gate reservoir to demonstrate downstream effectiveness and evaluate the potential for adverse effects on nutrient levels and thermal stratification; and (3) provisions to fully model, compare, and evaluate a variety of technologies, including but not limited to liquid oxygen

injection (intake and draft tube), gaseous oxygen injection (intake and draft tube), construction and operation of a multi-port selective withdrawal structure, and turbine venting, and include an assessment of effectiveness, cost, and potential effects.

FWS recommends that PacifiCorp's proposal to install a hypolimnetic oxygenation system at Iron Gate reservoir be studied further to demonstrate downstream effectiveness and the potential for adverse effects on nutrient levels and thermal stratification. PacifiCorp would also study the potential effectiveness of a hypolimnetic oxygenation system at Copco No. 2, and J.C. Boyle dams and the potential for adverse effects on nutrient levels and thermal stratification. These studies would provide recommendations to control DO content of reservoirs and released waters from reservoirs to meet salmonid fish requirements for the geographic extent of project DO effects without exacerbating algal blooms or disrupting reservoir thermal stratification. As part of these studies, the role of nutrient input and cycling would also be studied and remedies to the problems of hyper-eutrophication proposed. PacifiCorp would develop and submit to the Commission for approval a DO enhancement plan that would specify measures proposed for implementation, based on these studies. The studies and plan would be developed in consultation with the agencies and be fully implemented within 3 years of license issuance.

The Forest Service recommends that the DO level of water released from Iron Gate dam should be controlled to meet salmonid fish requirements for the geographic extent of project DO effect, without exacerbating algal blooms. The PacifiCorp-preferred design (hypolimnetic oxygen diffuser) would be studied further to demonstrate downstream extent of effectiveness.

Siskiyou County states they are in favor of appropriate terms and conditions that result in aeration of water in the reservoirs, if these practices have appropriate benefits. Conservation Groups recommend that PacifiCorp operate the project in a run-of-river mode to enhance DO, such that the amount of water entering an impoundment is equal to the sum of water passed over the dam, through fish passage facilities, and through the turbines at any given point in time, at every relevant facility structure.

Our Analysis

We have seen no evidence that operation of the project in run-of-river mode, as recommended by the Conservation Groups, would increase the DO in the outflows of any of the project reservoirs. Low DO concentrations observed in project reservoirs are likely the result of high BOD in the water column, stemming from high levels of organic material, rather than the peaking and re-regulating operations of the dams. Operating the project in run-of-river mode would continue to draw water from the existing intakes and comparable depths and would result in DO levels that are similar to levels released from project structures under existing conditions.

Currently, DO concentrations measured at flows above 1,000 cfs in the J.C. Boyle peaking reach meet applicable state objectives (figure 3-34). When the J.C. Boyle powerhouse is operating in peaking mode, generation flows are released only during the day. Non-generating flows in the peaking reach are supplied from the natural seep in the bypassed reach (typically between 220 and 250 cfs) and the current minimum flow of 100 cfs releases at the dam. Typically, summer DO concentrations are higher in a reservoir during the day, when photosynthesis produces oxygen, than at night, when respiration depletes oxygen. If J.C. Boyle were to operate in a run-of-river mode during the summer, generation flow releases from the powerhouse would be relatively constant over a 24-hour period. Releases during the daytime would contain higher concentrations of DO, and the increase in concentrations in the peaking reach via natural aeration would be limited. The resultant increased flow at night would create more favorable conditions for a re-aeration from the turbulence in the peaking reach because oxygen dissolves more readily in water with low DO. It is uncertain whether increased DO uptake at night in the peaking reach would influence the DO regime in downstream Copco reservoir.

Our review of available DO data and modeling results from downstream of Iron Gate dam indicates that during the warmer months of the year, project operations results in DO that does not meet

applicable water quality objectives. Therefore, measures to enhance DO downstream of Iron Gate should be implemented. Implementation of PacifiCorp's proposal to inject oxygen into the bottom waters of Iron Gate reservoir during times of low DO concentrations would increase DO concentrations within the reservoir; however, based on our review of PacifiCorp's assumptions of oxygenation efficiency and the measured DO concentrations at a depth of 40 feet (the powerhouse intake depth) during the summer and fall months, we conclude that the proposed diffuser technology may not be sufficient to meet state water quality objectives for DO downstream of the dam. The average DO concentration in Iron Gate reservoir from July to October at a depth of 40 feet was between 1.1 and 4.9 mg/L during 2000 to 2004 and the oxygen delivery capacity of the conceptual design is based on providing 1 to 3 mg/L of DO uptake.

In addition to our concerns regarding effectiveness, implementation of a hypolimnetic oxygenation system, although designed to enhance DO concentrations, may produce undesirable or unanticipated secondary effects. PacifiCorp's hypolimnetic oxygenation modeling (PacifiCorp, 2005i) predicts there would be a slight rise in outflow temperatures in August and September when forced oxygenation or aeration is applied. PacifiCorp credited this to a complex relationship with algae shading; however, several agencies question the ability of the model to capture the complex interactions created by adding oxygen to the bottom of such a eutrophic reservoir. Wells (2004) points out that it is difficult to account for the complex relationship of nutrients, algae, and DO concentrations in models that are currently available. However, he suggests that without factoring such considerations into the modeling, the results may not predict actual DO and temperature outcomes. Although we agree that modeling temperature and DO in stratified eutrophic reservoirs may have drawbacks, it is the best available tool for predicting outcomes of various alternatives. General trends shown by the model results can serve a valuable purpose with regard to the potential results of implementing environmental measures, during the planning stages, as long as the limitations are understood. However, the uncertainty of modeling results emphasizes the importance of verifying actual environmental responses by data collection in the field.

Turbulence created as oxygen rises through the water column would also likely alter the location of the thermocline, or possibly eliminate it. If this occurs, the potential for cool, hypolimnetic releases to lower the water temperature downstream of Iron Gate dam would be reduced. PacifiCorp's modeling results show that conditions with higher DO concentrations exhibit greater concentrations of inorganic nutrients (e.g., nitrate-nitrite) compared to nutrients bound to organic molecules, which may exacerbate algae blooms because algae can more readily assimilate inorganic nutrients. The modeling results showed oxygenation of the reservoir slightly decreased ammonia, noticeably decreased orthophosphate, and substantially increased nitrate-nitrite in the outflow between mid-July and mid-October. The ammonia and orthophosphate results are consistent with monitoring results taken before and after installation of a hypolimnetic oxygenation system in Comanche reservoir in California (Beutel, 2005). Chlorophyll *a* concentrations in Comanche reservoir decreased to about a quarter of that measured prior to hypolimnetic oxygenation, which is the opposite of what PacifiCorp's model predicts.

Increased amounts of inorganic nitrogen released downstream could affect the growth of attached algae in the river below the dam because the Klamath is nitrogen limited, as described in our discussion of the affected environment (see section 3.3.2.1.2, *Water Quality*). Kier Associates (2006) states that beginning at the outlet of Iron Gate dam, dense mats of periphyton and aquatic plants cover the river bed during the summer and are extremely efficient at removing nutrients. Within approximately 40 miles above the Scott River at RM 146.12, most inorganic nitrogen has been removed from the water column. This increased inorganic nitrogen and aquatic plant growth below Iron Gate dam could have other unwanted effects, such as increasing suitable habitat for the intermediate host of the salmonid pathogen *C. shasta*, discussed in the following subsection, *Monitoring and Control of Algae that Pose a Risk to Fish, Wildlife, and Public Health.* In light of our analysis, additional study of hypolimnetic oxygenation is warranted prior to implementing such a program in order to determine if the expected environmental benefits would outweigh any adverse environmental effects.

Oxygen or air injection into the turbines would increase DO levels in project outflows without the associated potential consequences of a hypolimnetic oxygenation system. The need for DO enhancement downstream of Iron Gate dam is immediate, especially during dry or critically dry years. Turbine air venting, which PacifiCorp's consultant estimates could increase DO in the Iron Gate dam tailwaters by at least 2.2 to 2.7 mg/L, depending on the configuration (Mobley, 2005), could be implemented with relatively minor adjustments to the turbine headcover or draft tube. However, Mobley (2005) also indicates that turbine venting could increase total dissolved gases to unacceptable levels. Implementing turbine venting would provide some short-term relief during periods of low DO, enabling alternative long-term DO enhancement solutions to be further evaluated (in the context of remedial measures) to address other water quality issues in project waters. Increasing the amount of air in the existing turbines is not without consequences; spot sampling of TDG done by PacifiCorp in 1994 below Iron Gate dam recorded values higher than 110 percent on two occasions and attributed the cause to large amounts of air mixed with water in the turbines to prevent cavitation. PacifiCorp (2004a) notes that these samples were taken when the powerhouse was operating at flows below turbine efficiency (low flow drought conditions) passing 500 cfs. Elevated TDG levels may be reduced with modifications to the turbines or through adaptive operations based on monitoring results. Depending on the results of DO and TDG monitoring in the tailwaters, turbine venting may also represent a viable long-term solution to the existing DO problem. Monitoring DO and TDG in the tailrace, as well as in the reservoir adjacent to the Iron Gate powerhouse, would provide data regarding the effectiveness of this approach, whether modifications to the venting system are needed, and whether supplemental or alternative DO enhancement measures should be considered.

Improving the DO concentration of the upstream hydro releases could further assist PacifiCorp in meeting DO objectives downstream of Iron Gate dam. As a supplement to air or oxygen injection at Iron Gate, injection could also be provided at Copco No. 1 or No. 2 powerhouse turbines which would increase DO concentrations of water entering Iron Gate reservoir. Flows from Copco No. 2 powerhouse would be discharged to the epilimnion of Iron Gate reservoir and the density of the relatively warm, oxygenated water would not likely be great enough to penetrate the thermocline. This would shorten the residence time of this water as it passes through Iron Gate reservoir because the oxygenated inflow would pass over the denser water to the intake of Iron Gate powerhouse. As figure 3-25 shows, water that flows through the powerhouse is primarily drawn from a location near the surface. Figure 3-35 (DO profiles) shows that, during the summer, the top few meters have high concentrations of DO while concentrations drop off substantially after 5 meters. Increasing the DO concentration in the top 10 meters of Iron Gate reservoir should translate to enhanced DO concentrations in the Klamath River downstream of Iron Gate dam. DO monitoring in Copco No. 2 and Iron Gate reservoirs coupled with DO monitoring in the Iron Gate tailwaters would document the effectiveness of such an approach, if implemented.

Spillage from project dams would increase downstream DO and may be appropriate for consideration in a comprehensive DO enhancement plan. This method could be used at times when spills would not result in inappropriate increases in water temperature downstream of Iron Gate dam, such as in May or June; however, DO concentrations at this time of year are typically above state objectives. Spillage at Copco No. 2 dam during certain times would increase DO of water entering Iron Gate reservoir through the relatively steep Copco No. 2 bypassed reach by using natural aeration from turbulence. This approach could be triggered by target DO concentrations in Iron Gate reservoir or downstream and may be more effective than direct air or oxygen injection at Copco No. 2 powerhouse. Using spillage to increase DO downstream of Iron Gate could also be achieved without the potential negative effects on nutrients and temperature that could occur with hypolimnetic oxygenation. TDG measurements taken below Iron Gate dam during spill events associated with maintenance in May 2002 (flow ranged between 1,490 to 1,719 cfs) never exceeded 110 percent, supporting the idea that spillage could be a viable way to increase DO levels without consequences from TDG (PacifiCorp, 2004a).

Monitoring DO and TDG concentrations in the outflows of Iron Gate near the USGS gage would assist in the management of an air or oxygen injection system at the turbines or within the waters of the reservoir while providing data for compliance monitoring. Incorporation of additional water quality parameters and locations would further assist PacifiCorp and appropriate parties in evaluating the effectiveness of any implemented measure and its effects on water in the reservoir. Development of additional studies to increase the understanding of relationships between enhanced DO concentrations and nutrient and algae dynamics, as recommended by NMFS, FWS, and the Forest Service, are actions similar to measures that would occur in PacifiCorp's proposed reservoir management plans, discussed later under *Project-wide Water Quality Management*. Distribution of PacifiCorp's plans to appropriate agencies for review and comment prior to filing with the Commission would ensure that the study plans address the best available technologies, resources, and monitoring techniques to ensure the chosen strategy would improve water quality. Implementation of air or oxygen injection systems at Copco No. 1 and 2 powerhouses, spillage at dams, or hypolimnetic oxygenation, if appropriate, could be initiated over time under an adaptive tiered approach, based on feasibility analysis and monitoring. A reasonable time frame for completing this adaptive approach would be 5 years (during which one or more additional DO enhancement measure may be implemented, if needed).

Monitoring and Control of Algae that Pose a Risk to Fish, Wildlife, and Public Health

During summer 2005 (Kann and Corum, 2006), and 2006 (Water Board, 2006), Copco and Iron Gate reservoirs experienced substantial and sustained blooms of the blue-green algae, *Microcystis aeruginosa*, and accompanying high levels of microcystin, a toxin often produced by this algae. These algal blooms were detected starting in mid-July and lasted through most of October. During much of this period, cell density levels of *Microcystis aeruginosa* and microcystin toxin concentrations exceeded threshold levels identified by the World Health Organization as posing a Moderate Probability of Adverse Health Effects. The state of California and federal agencies have not yet adopted regulatory numerical criteria for cyanobacteria and their toxins, but the Hoopa Valley Tribe (recently granted "Treatment as a State" status by the EPA for the purposes of implementing the CWA) has adopted criteria for *Microcystis aeruginosa* and microcystin for the Klamath River on the Hoopa Valley Indian Reservation (which intersects the Klamath River near the confluence of the Trinity River). For recreational waters, the Hoopa Valley criteria are a *Microcystis aeruginosa* cell density <50,000 cells/ml and <10 micrograms/L total microcystins (Hoopa TEPA, 2006). Although the toxic algae *Microcystis aeruginosa* has been known to occur regularly in Upper Klamath Lake (Gilroy et al., 2000), where it may degrade the quality of commercially harvested populations of the blue-green algae, *Aphanizomenon flos-aquae*, and as far as 190 miles downstream of the project reservoirs in the Klamath River Estuary (Kann, 2006), this was the first time the extent of the blooms and their toxicity, at locations other than Upper Klamath Lake, had been documented and health advisories issued by public agencies (Water Board) for project waters.

In addition to the toxic algae, the fish pathogens *C. shasta* and *Parvicapsula minibicornis* occur throughout the Klamath Basin and are a source of mortality to migrating salmonids throughout the Klamath River. PacifiCorp's investigation into *C. shasta* and its intermediate polychaete host *Manayunkia speciosa (M. speciosa)* indicates that habitat for the polychaete is available in areas of the project, primarily in free-flowing stretches of the river and riverine segments of the reservoirs (PacifiCorp, 2004f). The study of *C. shasta* is complicated by the fact that the pathogen changes form and apparently function, and has multiple hosts (juvenile fish and a polychaete alternate host) (Stocking and Bartholomew, 2004). Benthic sampling efforts within the Klamath River discovered the highest densities of the polychaete worms were always found within dense populations of the attached algae *Cladophora* (PacifiCorp, 2004f). One hypothesis for the high incidence of *C. shasta* in the Klamath River is that the polychaete populations have increased as a result of an increase in available habitat, most notably *Cladophora* (Stocking and Bartholomew, 2004). Bartholomew and Cone (2006) recently found the fish pathogen *P. minibicornis* requires the same worm host as *C. shasta*, thus, conditions that support *Cladophora* growth could enhance the prevalence of both fish pathogens. *Cladophora* populations, as

well as other populations of aquatic vegetation, increase when nutrients enrich areas of suitable habitat. Whether or not the project contributes to nutrient enrichment is a complex issue, as discussed in the following subsection, *Project-wide Water Quality Management*. We discuss the effects of *C. shasta* and *P. minibicornis* on salmonids in section 3.3.3.2.3, *Disease Management*.

PacifiCorp proposes to implement Reservoir Management Plans aimed at reducing algae concentrations, increasing dissolved oxygen, and improving pH. The Reservoir Management Plans would be designed to evaluate the effectiveness and feasibility of several technologies and measures (specifically hypolimnetic oxygenation, epilimnetic or surface aeration and/or circulation, and copper sulphate algaecide treatment) for more effectively controlling water quality conditions in the reservoirs. Although relevant to the control of algae in project waters, we discuss this measure, as well as recommendations of others that could reduce nutrient loading and thus control algal blooms, in the following section, *Project-wide Water Quality Management.*

FWS recommends that PacifiCorp develop a monitoring program, in consultation with other agencies, to assess the risk of toxic cyanobacteria blooms in Iron Gate and Copco reservoirs on fish health and the environmental factors that lead to such blooms and their adverse effects on fish. A plan would be developed, in consultation with the agencies, and implemented to reduce the risk of cyanobacteria blooms on fish.

Siskiyou County recommends that PacifiCorp provide for the removal of those species of blue-green algae that are a hazard and risk to health and safety of people and animals during the summer period when algae blooms occur. Conservation Groups recommend that PacifiCorp monitor for *Microcystis aeruginosa* in Copco and Iron Gate reservoirs and locations on the Klamath River affected in past years, downstream to the estuary, and at appropriate trigger points take appropriate actions (consult with public health authorities and public notification).

Our Analysis

The perceived public threat posed by toxins from cyanobacteria, such as *Microcystis aeruginosa,* to water supplies has increased world-wide during the past 30 years (World Health Organization, 1999). It is difficult to state that the actual public threat also has increased during this period, because toxins associated with cyanobacteria are only recently beginning to be understood and may have previously gone undetected because of a lack of monitoring. The World Health Organization (1999) also reports that health problems attributed to the presence of *Microcystis* in drinking and recreational waters has been reported in a number of countries, including Australia, Brazil, China, England, South Africa, and the United States. In a study of selected water utilities throughout the United States and Canada during 1996 and 1997, microcystins were found in 65 percent of water samples that had not undergone treatment and a third of the positive samples registered levels of microcystins in excess of the World Health Organization standard of 1.0 microgram per liter (Environmental Health Perspectives, 1999). Routine searches of public agency health-related websites throughout the country result in documentation of increasingly large numbers of health advisories pertaining to *Microcystis* and other cynobacteria in natural lakes and reservoirs. This is not a problem unique to the Klamath River.

Monitoring of cyanobacteria and cyanotoxin concentrations is more difficult than monitoring many other waterborne pathogens, because variations in cyanobacterial quantities, in time and space, are substantial, particularly if scum-forming species such as *Microcystis aeruginosa* are dominant (World Health Organization, 1999). The World Health Organization (1999) reports that wind-driven accumulations and distribution of surface scums can result in variations of concentrations of the toxin by a factor of 1,000 or more, and such situations can change within hours; therefore, discontinuous samples only provide a fragmentary insight into the potential cyanotoxin amounts present in any body of water. The lack of standardized methods to perform scum grab samples and the fact that scum samples are not

representative of average water concentrations further complicates the ability to characterize a *Microcystis* bloom. The Siskiyou County Public Health Department has consistently expressed its concerns about algae sampling and the lack of approved and standardized laboratory methods for monitoring microcystin (memo from T. Barber, Siskiyou County Department of Public Health, to C. Walden, Our Klamath Basin Water Crisis, dated March 9, 2007, posted at www.klamathbasincrisis.org, on March 17, 2007, accessed on March 19, 2007).

Microcystis aeruginosa has appeared regularly in Upper Klamath Lake, and has been documented within and downstream of Copco and Iron Gate reservoirs in each year since 2002 (Kann and Corum, 2006; PacifiCorp, 2007c). It is possible that *Microcystis aeruginosa* blooms may have occurred in project reservoirs prior to 2002. However, in the absence of a structured monitoring program, any previous occurrence of toxic algal blooms may have been undetected. Reynolds et al. (1981) reports that *Microcystis* is capable of over wintering in lakes and reservoirs and the colonies that over winter serve as new colonies when their habitat becomes hospitable.

Commission regulations specify that hydropower project licensees provide reasonable public access to project lands and waters, as long as public safety is protected. The public currently enjoys water-based recreational activities, such as swimming, angling, and boating at facilities at all project reservoirs. The toxin produced by *Microcystis* represents a potential threat to public safety. A structured monitoring program, developed in consultation with resource and public health agencies, based on known life history characteristics of *Microcystis,* would enable monitoring to occur and, if necessary, public health advisory notices to be posted when microcystin levels in the water reach threshold values. A monitoring plan to identify conditions when blooms could potentially occur in each project reservoir would enable triggers for the initiation of monitoring events to be established, and avoid unnecessary monitoring. Provisions for updating the plan would enable the monitoring program to be modified to reflect new information about *Microcystis* as it becomes available, and conditions that could lead to monitoring prior to potential blooms refined.

If a monitoring program is implemented for *Microcystis* and its toxin in project reservoirs, monitoring results that trigger public health agency notification would enable such agencies to make a determination regarding whether there is a health risk to the public who come in contact with Klamath River water downstream of Iron Gate dam. Because algal blooms typically occur in reservoirs, not in free flowing river reaches, we expect the concentration of microcystin downstream of reservoirs where trigger levels may be detected, to be lower and less toxic; however, Fetcho (2006) and Kann (2006) report *Microcystis* and microcystin as far down river as the Klamath River estuary. Consequently, we find that monitoring for *Microcystis* in free-flowing portions of the Klamath River from Iron Gate dam to the estuary, as Conservation Groups recommend, would be appropriate as a condition of any new license that may be issued for this project. Once detected, it may not be possible or feasible to remove *Microcystis* from project waters, as recommended by Siskiyou County. However, consideration of methods to reduce nutrient loading that create algal blooms and environmentally acceptable methods to control algal blooms when they occur, could be incorporated into the development of an overall water quality management plan, discussed in the following section.

Cladophora spp. is considered a nuisance algae capable of covering the entire stream bed. Schönborn (1996, as cited in Stocking and Bartholomew, 2004) found that *Cladophora* can displace all other aquatic macrophytes (individual aquatic plants large enough to be seen with the naked eye) due, in part, to a competitive advantage in nutrient enriched waters. This prolific, complex, and aggressive organism is considered an "ecosystem-reorganizer" capable of altering benthic food webs and centralizing the ecosystem by collecting fine organic matter and creating its own habitat (Schönborn 1996 as cited in Stocking and Bartholomew, 2004). Stocking and Bartholomew (2004) link increases in *C. shasta* infections in juvenile salmonids with the spread of *Cladophora* in the Klamath River, as the upstream eutrophic reservoirs supply a steady flow of warm, nutrient-rich water to downstream river reaches. Stocking (2006) has shown that the primary habitat for the polychaete host for both *C. shasta* and *P.*

minibicornis is sand with fine benthic organic matter and that the filamentous green algal *Cladophora* is a secondary habitat type. Polychaetes living on sand with fine benthic organic matter substrate are restricted to low-velocity areas, whereas polychaetes can exist in *Cladophora* in areas with higher water velocities (Stocking, 2006). Furthermore, sand substrate is susceptible to scour and active bed movement in response to increased velocities, whereas attached algae such as *Cladophora* may be able to withstand higher velocities providing a relatively stable habitat for the intermediate polychaete host. Stocking (2006) sampled an extremely large and dense population of polychaetes at Tree of Heaven (around RM 170) in March 2005. When Stocking returned to sample again in July, after a high-flow event (discharge below Iron Gate Dam peaked at 5,380 cubic feet per second on May 18), much of the organic matter was gone and all polychaetes had disappeared (presumably both had been washed downstream). In contrast, polychaete populations in *Cladophora* beds remained intact. Eilers (2005) recorded decreased biomass of attached algae downstream of Iron Gate dam following a doubling of released flow (from about 600 cfs to about 1,300 cfs) a week prior to his field work.

FWS pathogen monitoring of juvenile salmonids in the Klamath River during spring of 2006 showed 10 incidences of *C. shasta* infection out of 391 (2.6 percent) samples taken through the second week of June (memo from K. True, FWS, to the Klamath Fish Health Distribution List, dated June 8, 2006, accessed at http://ncncr-isb.dfg.ca.gov/KFP/uploads/2006%20pathogen%20monitoring%2009-15.doc on October 30, 2007). Flows in spring of 2006 (up to 10,000 cfs) were substantially above median levels (as described in section 3.3.2.1.1, *Water Quantity*) suggesting that increased flows may be capable of moderating the infection rates in juvenile salmonids, possibly by displacing or disrupting the growth of either the attached algae or the ability of the host polychaete to exist within the *Cladophora* habitat. FWS pathogen monitoring in 2005 detected juvenile salmonid infection rates of up to 100 percent of both *C. shasta* and *P. minibicornis* (FWS memo undated. Accessed on July 7, 2006, via: http://ncncr-isb.dfg.ca.gov/KFP/uploads/KR%20pathogen%20monitoring%20summary%2005-26-05.doc; last updated May 31, 2005). Reclamation classified 2005 as a "below average water year" (Reclamation, 2005c) where flows were well below the median during the time of recorded infections. Continued high nutrient levels in the Klamath River that create ideal colonization conditions for *Cladophora*, at sites with favored flow and substrate conditions, would enable the host polychaete to become reestablished, and *C. shasta* and *P. minibicornis* would likely continue to pose a serious threat to downstream salmon for the foreseeable future. However, by using information gathered during years when *C. shasta* infestations are low, such as 2006, it may be possible to develop methods to minimize future infestations by using controlled flows that displace either *Cladophora*, the hard substrate on which it grows, or the intermediate polychaete hosts that use this algae as its preferred habitat. We discuss the threat of *C. shasta* and *P. minibicornis* on anadromous fish and plans to control such threats in section 3.3.3.2.3, *Disease Management*, and the influence of flow on substrate conditions and active bed transport are discussed in section 3.3.1.2, *Geology and Soils*.

The presence of the blue-green algae *Aphanizomenon flos-aquae* in Upper Klamath Lake and its ability to fix nitrogen (convert inert nitrogen gas to more biologically available forms such as nitrite or nitrate) has been identified as a seasonally substantial source of nitrogen to Upper Klamath Lake (Walker, 2001; Oregon Environmental Quality, 2002b). Dense blooms of *Aphanizomenon flos-aquae* occur in Copco and Iron Gate reservoirs during July and August (PacifiCorp, 2004a), and are a source of nitrogen into project waters and releases downstream.

A reservoir management plan that limits the amount of inorganic nitrogen inputs would reduce suitable conditions for *Cladophora* colonization and reduce the risk of *Microcystis* as these organisms thrive under nitrogen rich conditions. Because *Aphamizonmeon flos-aquae* algae fixes nitrogen, which increases the amount of available inorganic nitrogen and could enhance the proliferation of downstream aquatic algae such as *Cladophora*, a reservoir management plan should address factors or conditions that support *Aphamizonmeon flos-aquae* blooms and identify measures that could be implemented to reduce such blooms in project reservoirs.

Project-wide Water Quality Management

As previously discussed, water quality within the Klamath River and throughout the mainstem portion of the project, is compromised for a number of water quality parameters which has triggered CWA 303(d) listings and the development of TMDLs, as well as other actions throughout the upper Klamath Basin. Numerous entities have filed comments that the project is a source of the poor water quality in the Klamath River and have filed recommendations designed to improve water quality to meet state standards.

Basin wide monitoring results show that Upper Klamath Lake is nutrient-rich, with hypereutrophic conditions observed during the summer. Project wide monitoring results show eutrophic conditions in all project reservoirs during the same time period. Project waters are typically high in total phosphorous and nitrogen, and experience extensive algae blooms during summer months resulting in high chlorophyll *a* concentrations. Upper Klamath Lake is undoubtedly responsible for a large portion of the nutrient loading downstream of Link River dam; however, there are additional inputs from the Lost River, Klamath Straits drain, and other non-point sources downstream of Keno dam (e.g., runoff from agricultural lands along the downstream portion of the peaking reach and adjacent to J.C. Boyle, Copco and Iron Gate reservoirs). In addition, nutrient cycling in the project reservoirs (Kann and Asarian, 2005; Campbell, 1999) increases the complexity of readily using predictive modeling to accurately understand the nutrient regime within the Klamath River. PacifiCorp states that the project does not contribute to nutrient loading on a net annual basis, arguing that the reservoirs act to trap sediments and the nutrients associated with them, thus improving downstream water quality. Previous nutrient loading investigations by Campbell (1999) and Kann and Asarian (2005) suggest that the project reservoirs act as both sinks and sources depending on the seasonal conditions within the reservoirs. Regardless, nutrient availability contributes to algae blooms of *Aphanizomenon flos-aquae,* a nitrogen fixing algae, in all mainstem Klamath River reservoirs, and attached algae growth downstream of the project which, as discussed in the previous section, has other undesirable environmental effects.

PacifiCorp, as part of their water quality certification application, proposes to develop comprehensive reservoir management plans aimed at reducing algae concentrations, improving DO, and improving pH in J.C. Boyle, Copco, and Iron Gate reservoirs (letter from C. Scott, Project Manager, PacifiCorp, to the Commission, dated May 12, 2006). The plans would include evaluation of technologies and potential effects of implementing them on the conditions resulting from the high nutrient and organic inputs. The plans would also provide for evaluating the appropriateness of treating algal blooms with copper-based algaecide. In addition, the plans would include further evaluation of hypolimnetic aeration (as previously discussed in *Dissolved Oxygen Remediation*) and epilimnetic or surface aeration/circulation. PacifiCorp expects that actions identified in the plans would achieve the following: reduced hypolimnetic BOD and ammonia (through oxidation of these compounds), reduced orthophosphate (through retention in sediments), and a decrease in algae populations in surface waters that would lead to decreased fluctuations in pH.

The Forest Service recommends that PacifiCorp work cooperatively to address cumulative effects on water quantity and quality in the Klamath basin through appropriate remediation such that water influenced by the project is of sufficient quality to meet or exceed applicable state objectives. The Forest Service further recommends that PacifiCorp study the feasibility of improving Klamath River nutrient levels in and downstream of project reservoirs by mitigating nutrients released in project river reaches and reservoirs, including offsite remediation to improve nutrient loading from Upper Klamath Lake.

Oregon Fish & Wildlife recommends that within 1 year of license issuance, PacifiCorp develop a water quality resource management plan, in consultation with Oregon Fish & Wildlife, and other state, federal, and tribal resource agencies. The plan would be updated every 5 years, in consultation with the agencies. PacifiCorp would submit annual reports to the Commission and the agencies that would include the annual work plan for the upcoming year and a report with narrative and graphs demonstrating

compliance with water quality requirements and standards for project reservoirs and reaches. The report would also include a summary of non-compliant events for the following parameters: water temperature, DO, TDG, pH, chlorophyll *a*, nutrients (including nitrogen and phosphorus), and toxic algae.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp implement mitigation measures and conduct water quality monitoring pursuant to the water quality management and monitoring plan(s) approved by the Oregon Environmental Quality and the Water Board in connection with the water quality certificates.

Our Analysis

Our review of available water quality information indicates that the Klamath River experiences tremendous nutrient inputs from upstream of the project and elevated nutrient concentrations within project reservoirs and downstream of Iron Gate dam. Generally, mean nutrient concentrations are reduced in the riverine reaches as compared to project reservoirs. Upper Klamath Lake and the surrounding agricultural lands are undoubtedly the source of much of the nutrient load in project waters; however, due to complex nutrient cycling dynamics, project reservoirs act as both a sink and a source of nutrients depending on the time of year.

PacifiCorp suggests that Copco and Iron Gate reservoirs trap and remove nutrients from the Klamath River. Table 3-30 shows the concentrations of total phosphorous, orthophosphate phosphorus, and ammonia in the hypolimnion of Copco reservoir increase in the summer, which could be used to support such conclusions; however, the concentration data alone are not enough to irrefutably support PacifiCorp's position. Nutrient load estimates by Kann and Asarian (2005) indicate that Copco and Iron Gate reservoirs act as sinks for the nutrients phosphorous and nitrogen during April, May, parts of July and August and October, but both reservoirs can act as a nutrient source to the Klamath River below Iron Gate dam during most of June and September. Likely pathways for this increased load include internal sediment loading and nitrogen fixation by cyanobacteria such as *Aphanizomenon flos-aquae*, according to Kann and Asarian (2005). Nutrient loading analysis was not available for the period from November through March, which could include the period of reservoir turnover when nutrients within the hypolimnion could become either available for transport downstream or undergo aerobically induced chemical processes that result in the formation of insoluble precipitates, which could settle out rather than be passed downstream. After settling to the bottom, nutrients would be released from the precipitates under anaerobic conditions the following year, resulting in an internal cycling of nutrients. Due to the limited field data, the net fate of the nutrients is not entirely clear. Our review of available temperature profiles for Copco and Iron Gate reservoirs (figure 3-24) indicates that in 2002, fall turnover likely occurred between September and October at Copco reservoir. In 2001, fall turnover likely occurred between October and November at Iron Gate reservoir. The potential effect of nutrient releases from Iron Gate development associated fall turnover on downstream aquatic habitat is unknown. Spawning adult fall Chinook salmon would be in the river during this time frame. The Water Board sponsored a follow-up study that broadens the temporal and spatial data collection that limited the Kann and Asarian (2005) study. This study (Kann and Asarian, 2007) confirms the results of Kann and Asarian (2005) that project reservoirs act as both sources and sinks of nutrients, but the alternating source and sink periods during 2005-2006 were not as apparent, as it was based on the 2002 data reported in Kann and Asarian (2005).

Results from Kann and Asarian (2005) are supported by an earlier investigation by Campbell (1999) who also concluded that the project reservoirs act as both nutrient sinks and sources. Campbell concluded that there is a general increase in phosphorus loading longitudinally from Keno to below Iron Gate dam which is not completely explained by increases in flow between the two sites and may be caused by internal nutrient cycling in the project reservoirs. Campbell further notes that although internal nutrient cycling in the project reservoirs was not quantified, the reservoirs in series do not seem to be functioning as a substantial nutrient sink between Keno and Iron Gate dam.

PacifiCorp acknowledges that Keno reservoir is seeded with algae passed from Link River, such that the same nutrient cycling dynamics occurring in Upper Klamath Lake also would be likely to occur in Keno and other downstream reservoirs. The total nitrogen balance developed for the Upper Klamath Lake TMDL indicates that Upper Klamath Lake is a seasonally important source of nitrogen (Kann and Walker, 2001). The primary source for this increase is internal nitrogen loading from nitrogen fixation by the blue-green alga *Aphanizomenon flos-aqaue* (Kann, 1998 as cited by Oregon Environmental Quality, 2002b). The ongoing Water Board nutrient balance study for Copco and Iron Gate reservoir should provide resolution of this complex issue at these reservoirs. We conclude, based on our review of the available information that Copco and Iron Gate reservoirs can, at times, act as sources of inorganic nitrogen during the summer, at least during relatively dry years primarily because the reservoirs create conditions that foster algal blooms of *Aphanizomenon flos-aqaue* and associated nitrogen fixation.

DO and pH in project-influenced waters are indirectly affected by nutrients because they are related to background water quality conditions, photosynthetic activity, and the amount of organic material exerting biological oxygen demand in the water. A shift in nutrient cycling in project reservoirs and outflow to inorganic nitrogen could act as a stimulant to enhance growth of attached algae in the Klamath River downstream of Iron Gate dam. Based on our review of available information, project reservoirs contribute to increased nutrient enrichment both within and downstream of project reservoirs on a seasonal basis, with associated related adverse affects (i.e., low DO during the summer and early fall and increased habitat for the *C. shasta* polychaete host, discussed in the previous subsection). Table 3-30 shows ammonia accumulates in the hypolimnion of both Copco and Iron Gate during the summer into October. Ammonia concentrations in the Klamath River above the confluence with the Shasta River were recorded at the highest levels in October, which is not unexpected under reduced conditions; however high levels in a well mixed environment such as the Klamath River at the confluence of the Shasta River (over 13 miles downstream of Iron Gate dam) suggests turnover at Copco and Iron Gate reservoirs or fish hatchery effluent could be responsible for the elevated ammonia concentrations. Ammonia can be toxic to fish. Therefore, we conclude that it is appropriate for PacifiCorp to assess measures to reduce such nutrient-related project effects, as PacifiCorp proposes and others recommend.

Enhancements to water quality (e.g., DO, pH, and algae) within the project area could be realized if the method of enhancement adequately controls the nutrients entering, already within, or internally loaded to the reservoirs. Wetlands, as recommended by the Forest Service, have proven to reduce nutrient concentrations in waters; however, given the loading from agricultural returns in the upper Klamath Basin, the most strategic potential locations are likely closer to the high nutrient effluent in the agricultural canal systems. Given the Commission's lack of jurisdiction over lands in these areas, alternatives to wetlands need to be explored. Controlling nutrients with aquatic vegetation and subsequent harvesting has been researched around the globe. Researchers in Thailand presented promising results of controlling nutrients in shrimp farm effluent with the use of duckweed (Ruenglertpanyakul et al., 2004) while researchers at the University of Florida worked with water hyacinth plants (Reddy, 1982, and Reddy et al., 1983) with promising results. Various models of a system for decreasing algal concentration consist of macrophyte vegetation (single plants, visible to the naked eye) and various permutations of floating boom, barrier, and water control mechanisms (pumps, internal barriers, etc.) for sequentially shading suspended algae-containing water, causing the algae to die off. The nutrients contained in the algal cells are released after the cells die, which makes them available for uptake by aquatic macrophytes within a containment system which can be moved around a water body. The aquatic macrophytes can then be readily harvested from the containment system, once nutrients have been removed from the water column (DeBusk and Haselow, 2006). Some aquatic plants that have been used effectively elsewhere to control nutrients, like water hyacinth, are considered invasive species in California, and therefore may not be suitable for use in project waters. However, the ability to remove floating plants from the water adds to their allure in that with enough effort they could be controlled should they escape the target area. Modifying the DO regime within the reservoirs is another method in controlling internal nutrient loading. Destratification of the reservoirs would mix the water

column, but this occurs at the expense of mixing the cold hypoliminon with the warm surface waters which would eliminate the primary source of cold water for the Iron Gate Hatchery.

Development of reservoir management plans, as proposed by PacifiCorp, would address conditions stemming both directly and indirectly from the high levels of nutrients in project waters. Assessing a variety of technologies for reducing algae concentrations and enhancing the DO and pH of project waters would identify potentially effective measures to be implemented to address known water quality problems. However, development of separate management plans for each project reservoir would make it more difficult to take a comprehensive approach to addressing water quality issues, as previously discussed in *Keno Reservoir Water Quality Management*. We consider a more effective approach to water quality management to include all project-affected waters in a single comprehensive water quality resource management plan, as recommended by Oregon Fish & Wildlife. By including all project reservoirs and free-flowing reaches influenced by the project (e.g., project bypassed reaches, the peaking reach, and project-influenced portions of the Klamath River downstream of Iron Gate dam) in such a plan, water quality monitoring and potential remedial measures would incorporate inter-relations of reservoir dynamics with those of free-flowing project reaches into deliberations on measures to be implemented.

We consider consultation with appropriate resource agencies in the development of any comprehensive water quality resources management plan to be essential. In some instances, potential measures for controlling water quality issues within project waters may entail balancing benefits against potential adverse effects. For example, applying copper sulfate is known to cause release of cell-bound microcystin into the water column, and depending on the algaecide used, there could be other associated adverse toxicity effects. Also, there could be associated adverse water quality effects. For example, as treated algae die and settle to the bottom of the reservoir, nutrients within the algal cells become susceptible for release and reintroduction to the water column at a later time (Touchette, 2005). Resource agencies that represent the local natural resources and the related public health interests should be involved in such decisions.

Although we agree with the Forest Service that offsite measures to reduce nutrient loading coming into the project could help control nutrient levels within the project-influenced portion of the Klamath River, we consider it appropriate to consider such measures in plans that address loading to the Klamath River from throughout the entire basin. For example, we conclude the forthcoming TMDL and Reclamation's CIP would address loads entering the Klamath River and we consider it unreasonable to assign to PacifiCorp the responsibility of nutrient removal prior to water reaching the project. However, provisions for periodic updates to a comprehensive water quality management plan specific to the Klamath Hydroelectric Project would enable parallel water quality enhancement initiatives to be incorporated into the plan, as appropriate. Although the outcome of PacifiCorp's proposed assessments of measures to control algae and related water quality problems associated with high nutrient and organic input may identify techniques that could be used directly in project waters, another possible outcome could be that it may be more effective to treat water before it is influenced by the project. Cooperation and coordination with other entities with an interest in addressing basin-wide water quality issues could lead to creative solutions to such issues. As discussed in *Keno Reservoir Water Quality Management*, assessing measures that would reduce the nutrient load of water passing from Keno dam, could effectively address project-related water quality issues at Copco and Iron Gate reservoirs. We discuss the basin-wide efforts targeting nutrients and other water quality analytes in section 3.3.2.3, *Cumulative Effects*.

Project operations contribute to water quality conditions that may affect the taste and odor of project waters and could affect the flesh of harvestable salmonids and other aquatic resources that occur within the river. Table 3-35 indicates that two-thirds of recreational users in the project area had negative perceptions of the water quality, commenting on its color, turbidity, and odor. Given the eutrophic conditions within the reservoirs and the nutrient and organic matter loading to the river, it is not unreasonable to imagine the water would have a distinctive taste. We have no information regarding what specific conditions are causing taste and odor complaints by recreational users, but given the

prevalence of algal blooms in project reservoirs, we suspect that such blooms are the likely cause of taste and odor problems. In addition to algal blooms, taste and odor issues at reservoirs are often associated with hydrogen sulfide, which produces a "rotten egg" taste and smell. Hydrogen sulfide production typically occurs as a byproduct of anaerobic decomposition of organic matter. Conditions that would allow hydrogen sulfide production (high organic matter and anoxic conditions) are present when Copco and Iron Gate reservoirs stratify in the summer. We have no direct evidence that this is the case at any of the project reservoirs, but it would not be unexpected. Methane production is strongly suspected as occurring in Iron Gate reservoir (Eilers and Eilers, 2004) and can produce taste and odor problems. Bastviken et al. (2004) indicates that methane production from lakes and reservoirs originates from anoxic sediments common under eutrophic conditions; stratified lakes with anoxic hypolimnions (methane is stored and released when the lake or reservoir destratifies); and from emergent vegetation along the margins of lakes and reservoirs. Copco and Iron Gate reservoirs both have anoxic hypolimnions and therefore may seasonally release methane. Keno reservoir (which does not stratify, but is eutrophic with fairly extensive abutting wetlands) and Upper Klamath Lake may be year-round sources of methane. Additional unpleasant odors could stem from the decomposition of algal mats that are attached to the shoreline providing a source of odors in areas visited by shoreline recreationists. A water quality management plan that includes measures that would reduce the likelihood of algae blooms, as well as enhance the DO of hypolimnetic water in Copco and Iron Gate reservoirs would also likely serve to reduce the taste and odor issues of project waters.

Dam Removal to Enhance Water Quality

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that if it is not feasible to meet water quality objectives for water quality certification through modification of project facilities and operations, PacifiCorp should prepare a decommissioning amendment application for the subject facility, in consultation with state, federal, and tribal stakeholders, in order to achieve compliance with applicable water quality objectives.

The Hoopa Valley Tribe states that "PacifiCorp's own analyses make it clear that the Klamath Hydro Project's effects on water temperature are immitigable; therefore, the only way to substantially reduce the impacts is to remove all KHP dams and drain the reservoirs." We consider this to be a recommendation for project dam removal to enhance the downstream water temperature regime for salmonids.

Conservation Groups recommend that PacifiCorp prepare a decommissioning plan in consultation with federal state, tribal, and other relicensing parties that results in the modification or removal of project facilities and operations to achieve compliance with all applicable water quality objectives.

Our Analysis

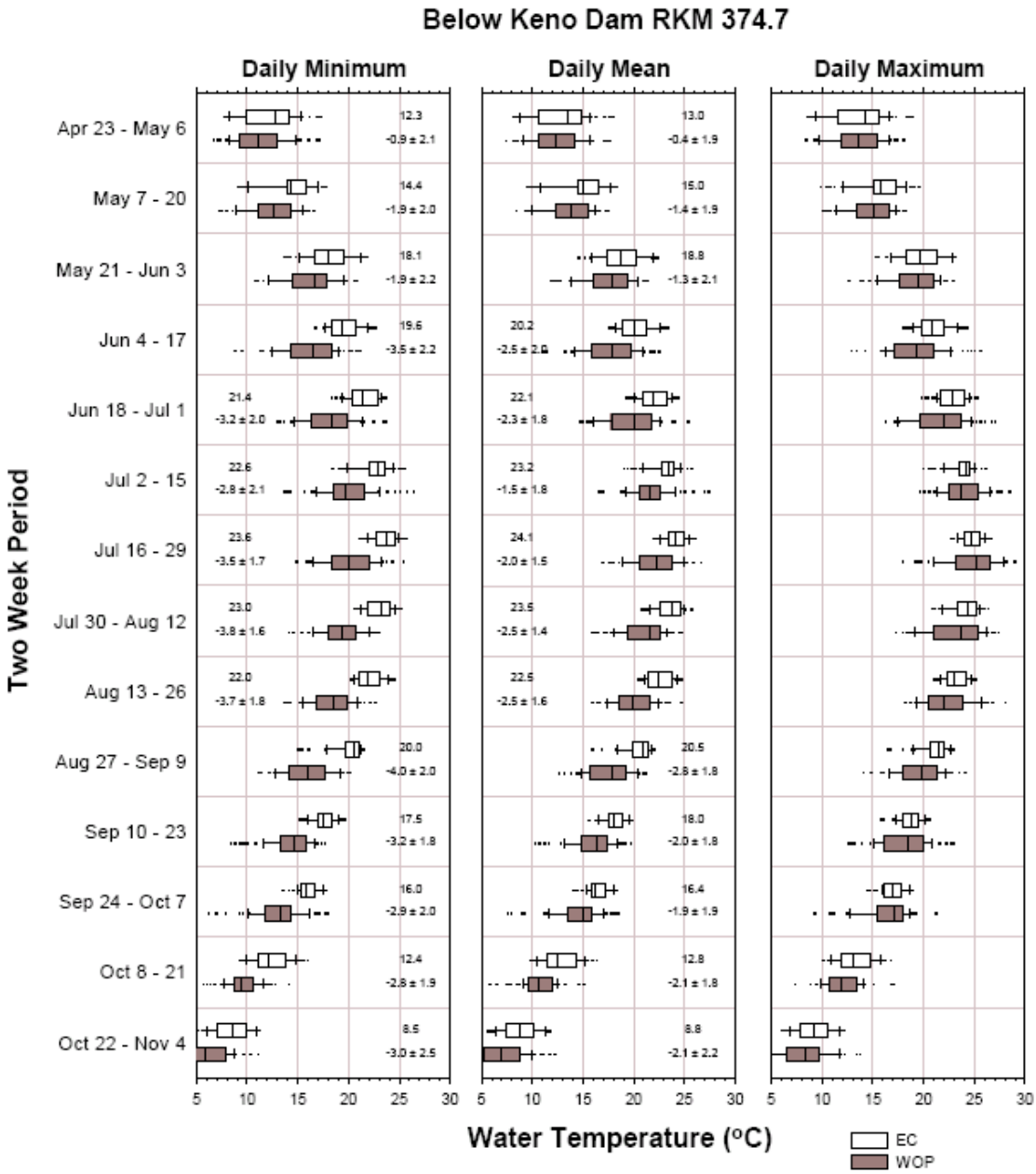
Both Oregon and California have listed project waters as "impaired" because they fail to meet applicable water quality objectives. We assess the potential effects on water quality resulting from removal of each mainstem dam because numerous parties have recommended the removal of some or all project dams. Many parties suggest that dam removal may be the only means to effectively address adverse project-related water quality effects. If project operation can be demonstrated to be responsible for continued non-attainment of applicable water quality objectives after implementation of reasonable measures, and it is not feasible to correct the problem, we consider it appropriate to consider decommissioning the development. However, we expect considerable effort to be expended to identify all options to correct the problem before decommissioning is considered. If water quality objectives are not met for reasons that are not related to project operations (e.g., the quality of water entering the development is similar to the quality of water leaving the development), after appropriate analysis to compensate for localized project-related effects, it would be inappropriate to consider decommissioning the development. We do not expect the Fall Creek diversion dams to have any long-term effect on water

quality. We do not consider removal of either diversion dam to be a reasonable option because applicable water quality objectives are currently being met. Therefore, we do not further discuss removal of these dams to achieve water quality objectives.

PacifiCorp's temperature modeling results show a Klamath River without hydroelectric dams would generally be warmer in the spring, more variable in the summer and fall (in particular, downstream of Iron Gate dam, as figure 3-50 shows), and similar to existing conditions between December and March. Unfortunately, because many of the other parameters in the model (e.g., pH, nutrients, and algae) are driven by much more complex biochemical processes than temperature,[62] modeling results for these parameters are contingent on the quality of the entire dataset and subject to variable interpretation. We base much of our analysis of the potential effects of dam removal on our review of existing water quality data from the riverine reaches and general principles that typically influence water quality. Without project dams and their associated reservoirs, the river would become well-oxygenated below the Keno dam site, due to mixing and reaeration afforded by natural river systems in steep, fast flowing environments. The Klamath River without project dams would still experience high levels of nutrients and organic matter originating from upstream sources, unless measures are implemented by other entities to reduce nutrient input. Given the high inputs to project waters, nutrients would continue to persist in project-area waters in the absence of water treatment by other parties, and it is likely that without treatment of water entering the Klamath River from Link River and the Klamath Irrigation Project, Klamath River water quality would continue to be impaired. More importantly, conditions that support planktonic algae, including *Microcystis, Aphamizonmeon flos-aquae*, and other species that cause blooms in project reservoirs, would be diminished because such algae do not thrive in free-flowing reaches with turbulent conditions, such as would exist without project dams. Therefore, the geographical extent of Klamath River impairment would likely be reduced with mainstem project dam removal.

Removal of Keno dam would result in substantial changes to the thermal regime in the formerly impounded area, as the surface area would be substantially reduced and the residence time of water passing through the former reservoir site would be decreased, thus reducing solar warming of the impounded water. However, inflow to the Klamath River from irrigation runoff and from Upper Klamath Lake would still be warm. Figure 3-52 shows the expected temperatures below Keno dam under a "without project" scenario summarized by 2 week intervals. Daily maximums under the without project scenario would be similar to existing conditions; however, the greatest differences would be in the daily minimums, which could be almost 4°C lower than the existing conditions during the warmest periods in July. Similarly, daily average temperatures would be lower without the project, with temperatures about 2°C lower during the same time period. We discuss the effects of such temperature differences on salmonid refugia in section 3.3.3.2, *Aquatic Resources*.

[62]Temperature is a physical process and as such is relatively simple to model, as the physics that affect it are well understood.



[a] Line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers.

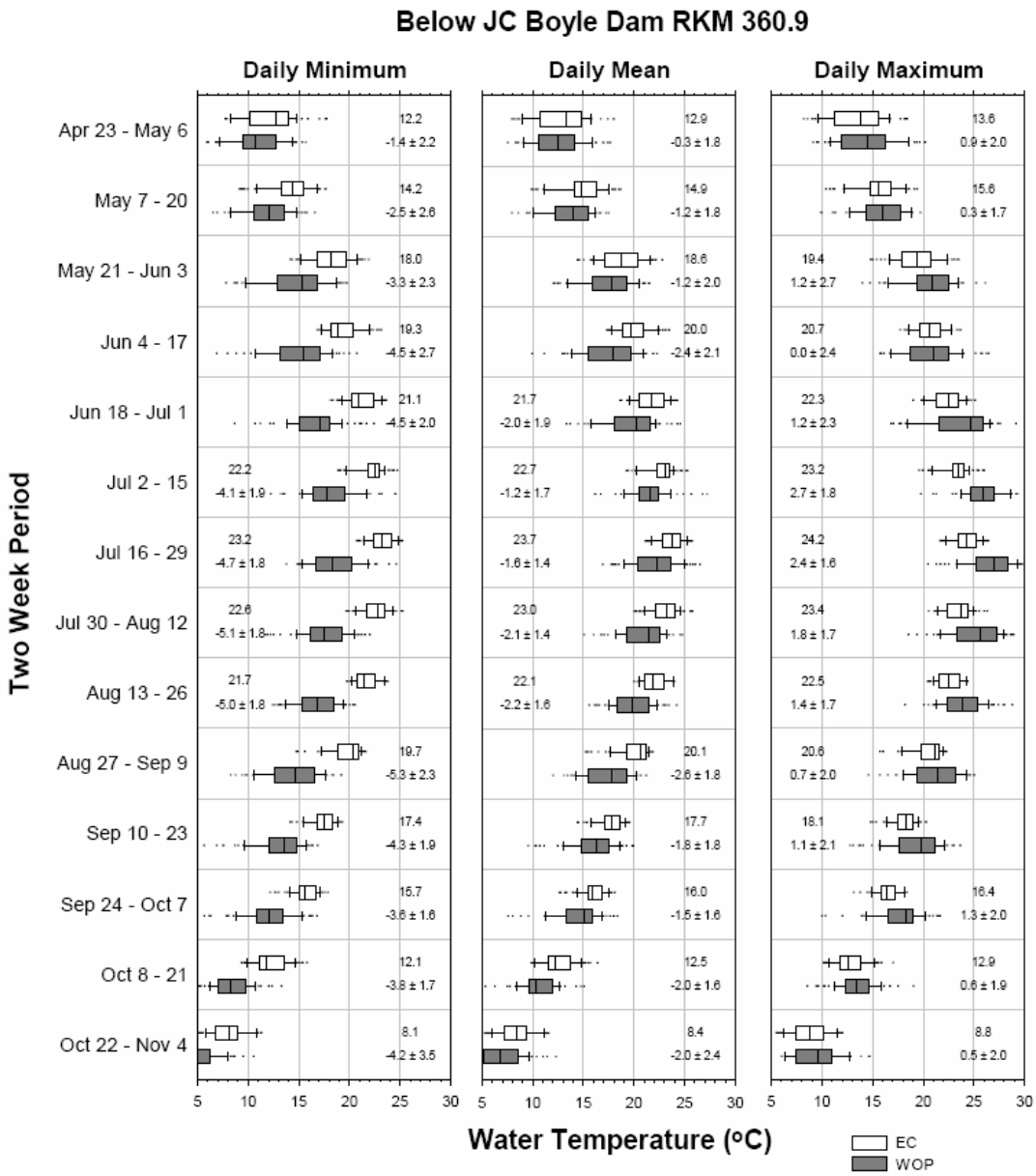
[b] Numbers adjacent to the box plots are the mean temperature under existing conditions (EC) (top) and the mean difference (without project [WOP] minus EC) ± 1 SD (bottom).

Figure 3-52. Box plots[a] of existing conditions and without project[b] daily minimum, mean, and maximum water temperatures from April to November for the years 2000 through 2004 below Keno dam predicted by PacifiCorp's Klamath River Water Quality Model. (Source: Dunsmoor and Huntington, 2006)

High nutrient inputs would be expected to continue absent implementation of a TMDL, but because the reach would be free flowing there would be a decrease in planktonic algae and a likely increase in attached algae (including *Cladophora spp*.) and submergent and emergent vegetation. Biggs (2000) reports that rivers around the world follow common patterns in response to localized nutrient enrichment. He states that, as long as additional nutrient inputs do not occur, nutrient concentrations typically diminish as the river flows downstream. Increased nutrient uptake by periphyton below a source is documented by USGS investigations on the South Fork Umpqua River in Oregon. USGS concluded that periphyton acts as an effective sink for nutrients entering the South Umpqua River (Tanner and Anderson, 1996). Removal of existing dams would shift the riverine nutrient distribution pattern depending on which dams are removed.

The continued loading of organic material from Upper Klamath Lake and the shallow nature of the relatively low gradient of the Klamath River currently submerged by Keno reservoir (see figure 3-2) are conditions that would persist post-dam removal and may continue to exert an elevated biological oxygen demand throughout the water column. This may result in a continuation of DO conditions that are similar to current conditions in that the high biological demand would compromise DO concentrations resulting in low DO levels. Because the portion of the Klamath River now impounded by Keno dam would be returned to a shallow river, high nutrient inputs would stimulate aquatic plant growth, which would also contribute to fluctuations in DO concentrations (NAS, 2004). If Keno dam is removed, the former Lake Ewauna would not serve to retain fine-grained sediment and associated nutrients and other contaminants, because the bedrock sill that formed Lake Ewauna was removed when the original regulating dam was constructed at Keno (see section 3.3.1.1, *Geology and Soils*). This could allow for some turbulence causing reaeration; however given the shallow, meandering nature of the reach this may only result in modest aeration and may not overcome the biological oxygen demand. In general, we expect changes in nutrient and DO concentrations in the former Keno reservoir area and the downstream Keno reach, if Keno dam should be removed, to be related to a shift from free floating planktonic algae to attached algae and emergent vegetation which could begin the nutrient assimilation process closer to the source of inputs.

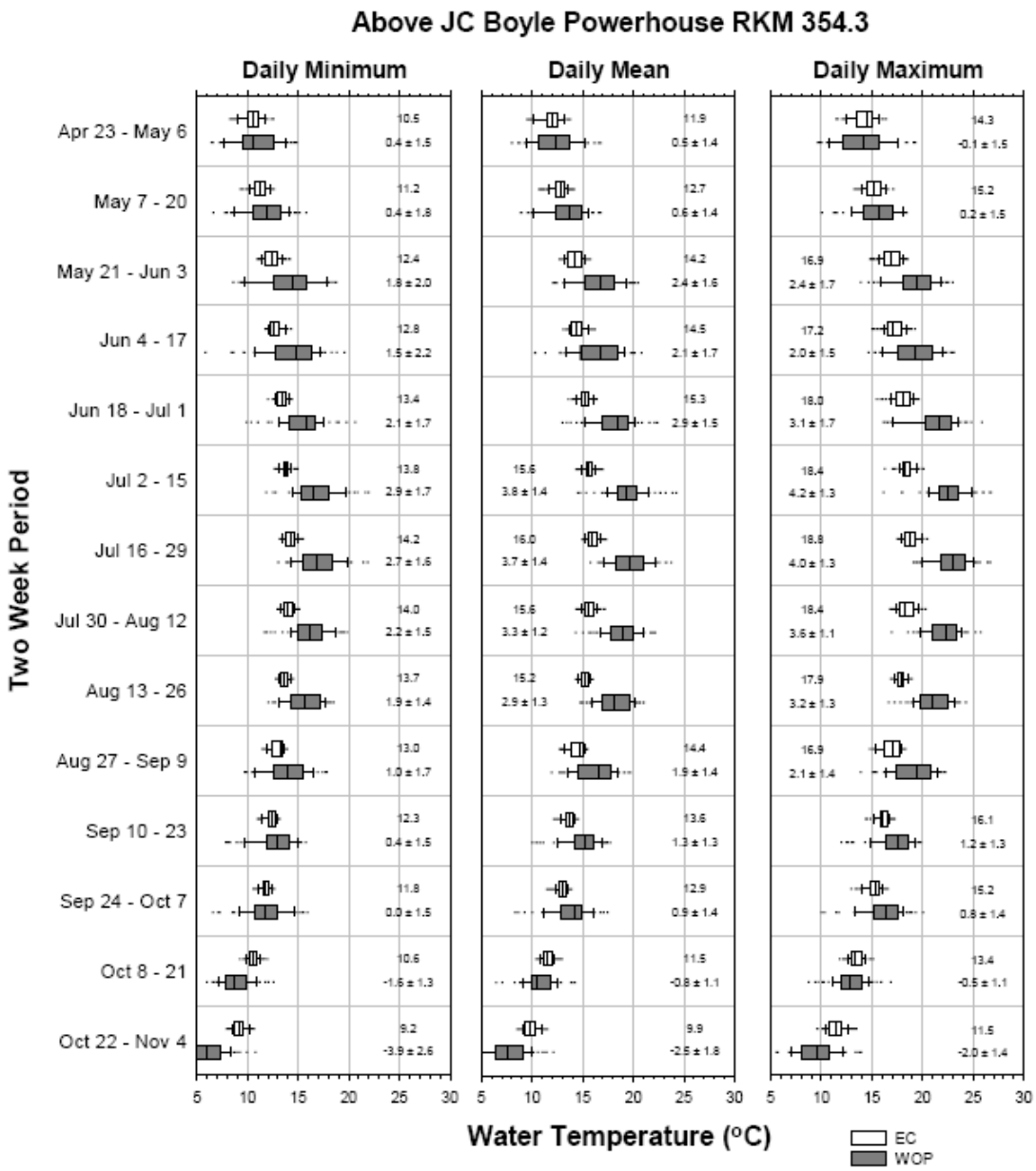
The Keno reach upstream of J.C. Boyle reservoir is generally steep, free flowing, and has a boulder type substrate, and waters entering J.C. Boyle reservoir are well aerated. Residence time in J.C. Boyle reservoir is short (about 3 days) compared to Keno, Copco, and Iron Gate reservoirs, which limits the amount of time for alteration of water quality directly related to the project, and the reservoir typically does not stratify. Little sediment has accumulated in the reservoir according to available information (see table 3-1). If J.C. Boyle dam would be removed, we expect there would be little effect on downstream water quality. The exception would be a substantial increase in water temperature in the J.C. Boyle bypassed reach because the increased volume of water would dilute the coldwater inflow from springs in this area. Similarly, the temperatures in what is now the peaking reach would be modified by eliminating the swings caused by peaking operations and the influence of the spring water in this reach during non-generation periods. Figure 3-53 shows the expected temperatures below J.C. Boyle dam above the natural springs in the bypassed reach and figure 3-54 shows the expected temperatures above the J.C. Boyle powerhouse, but downstream of the primary area of spring accretion, under existing conditions compared to a without project scenario. Below J.C. Boyle dam, temperatures under the without project scenario are expected to have increased variability with average daily maximums during 2-week intervals predicted to be as much as 2.7°C higher than under existing conditions and average daily minimums predicted to be as much as 5.1°C lower in July and August. Returning flows to the bypassed reach under a J.C. Boyle dam removal scenario are expected to dilute the 220 to 250 cfs of cool spring flows that begin entering the bypassed reach about 0.5 mile downstream of the dam, increasing temperatures over existing conditions. Because J.C. Boyle dam diverts flow away from the bypassed reach, flows within the reach are limited to groundwater spring seepage and the current 100 cfs minimum flow release from the dam, which results in artificially lower temperatures than would be expected without the dam in place.



[a] Line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers.

[b] Numbers adjacent to the box plots are the mean temperature under EC (top) and the mean difference (WOP minus EC) ± 1 SD (bottom).

Figure 3-53. Box plots[a] of 2-week summaries of modeled existing conditions and without project[b] daily minimum, mean, and maximum water temperatures from April to November for the years 2000 through 2004 below J.C. Boyle dam, above the springs within the bypassed reach, predicted by PacifiCorp's Klamath River Water Quality Model. (Source: Dunsmoor and Huntington, 2006)



[a] Line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers.

[b] Numbers adjacent to the box plots are the mean temperature under EC (top) and the mean difference (WOP minus EC) ± 1 SD (bottom).

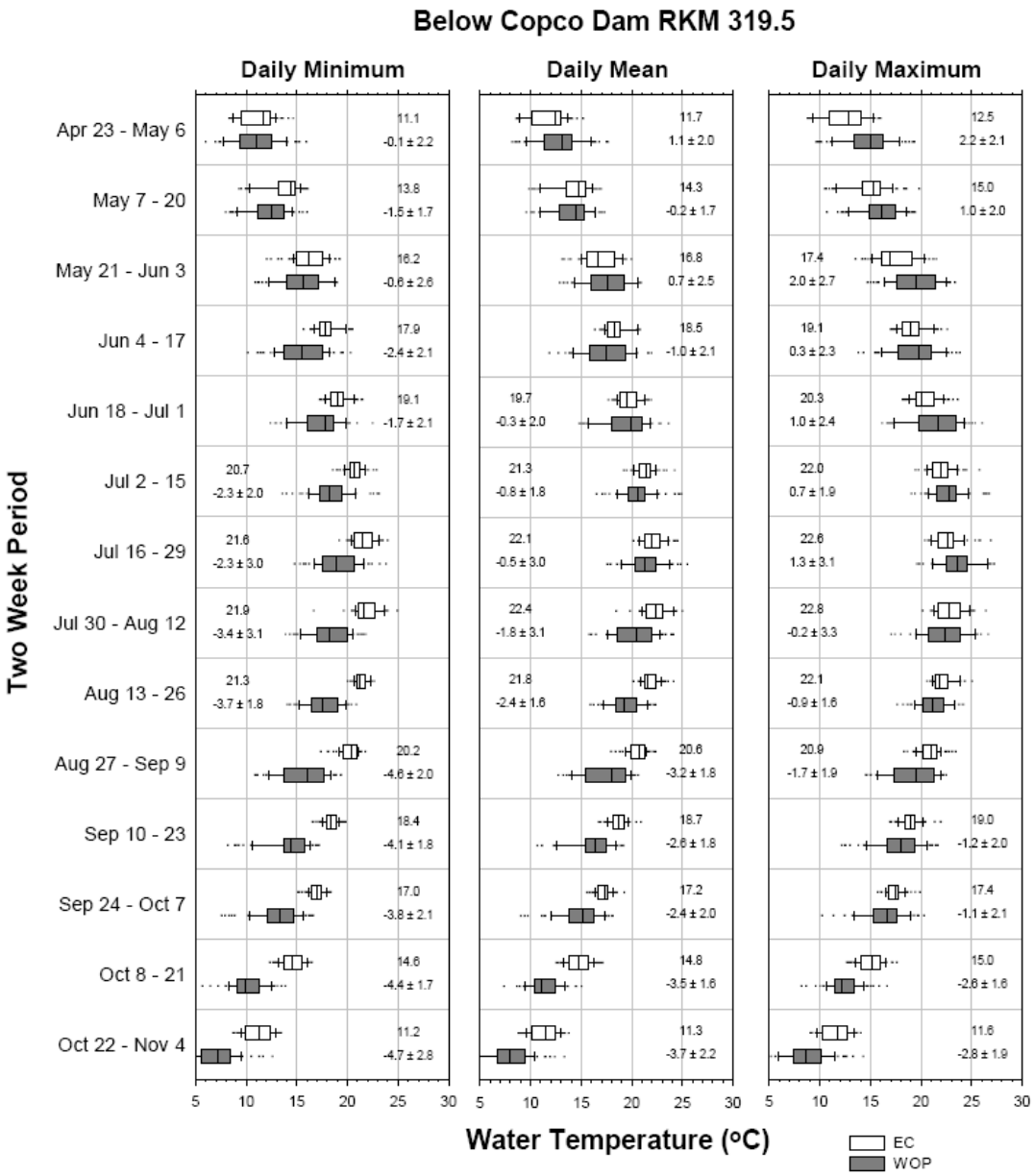
Figure 3-54. Box plots[a] of 2-week summaries of modeled existing conditions and without project[b] daily minimum, mean, and maximum water temperatures from April to November for the years 2000 through 2004 above J.C. Boyle powerhouse, below the springs within the bypassed reach, predicted by PacifiCorp's Klamath River Water Quality Model. (Source: Dunsmoor and Huntington, 2006)

Figure 3-54 shows that the average daily maximums during 2-week intervals without the dam are predicted to be as much as 4.2°C above existing conditions and the variability in temperatures would be expected to be much greater as well. The average predicted daily minimum temperature would be up to 2.9°C higher without J.C. Boyle dam, compared to existing conditions for the modeled 2-week interval. We discuss the loss of cold water salmonid refugia and the significance of temperature variability associated with this scenario in section 3.3.3.2, *Aquatic Resources*. In addition to the changes in temperature, the lack of peaking operations and a generally more stable flow regime would allow for aquatic vegetation and attached algae to persist in the channel. Aquatic vegetation and attached algae are currently precluded from realizing their full potential nutrient assimilation capacity due to the scouring effects of daily peaking operations. Vegetative scouring would likely still occur even if peaking occurs once a week, as the Bureau of Land Management specifies. Under a dam removal scenario, nutrient assimilation would likely be greater than under existing conditions, resulting in an upstream shift in the portions of the Klamath River that currently experience excessive nutrients.

Removal of Copco No. 1 and Iron Gate dams would result in the greatest effects on Klamath River water quality due to loss of their associated reservoirs. Without these two dams, we expect the Klamath River would experience reduced ammonia and pH fluctuations, as these conditions are associated with algae blooms, anaerobic decomposition, and stratification processes within the reservoirs, as well as a reduced risk of *Microcystis* blooms. Removal of Copco No. 1 and Iron Gate dams would likely result in changes in the distribution of attached algae and moderate DO and pH. Without Copco and Iron Gate, temperatures below Iron Gate would experience more diurnal variability than existing conditions; however this variability would not be as extreme as without project scenario predictions (PacifiCorp, 2005e). Figures 3-55 and 3-56 show the expected temperatures below Copco and Iron Gate dams under a without project scenario summarized by two week time periods. Below Iron Gate dam, daily minima without the project are lower than existing conditions from June through October, with the greatest differences occurring during August (3-4°C) and September through October (4-7°C). During mid-August to early September, nearly all daily means under existing conditions exceed 20°C, whereas most daily means without the project are below 20°C (Dunsmoor and Huntington, 2006). These results are similar to hourly predictions developed by PacifiCorp (see figure 3-50). We discuss the effects of such temperature differences on salmonid refugia in section 3.3.3.2, *Aquatic Resources*.

Removal of Copco No. 2 dam would return flows to the Copco No. 2 bypassed reach providing natural aeration from the turbulent passage of water over the coarse, steep gradient in this reach, thus improving DO. However, because of the lack of a sizeable impoundment and associated lack of stratification, we do not expect additional effects on water quality.

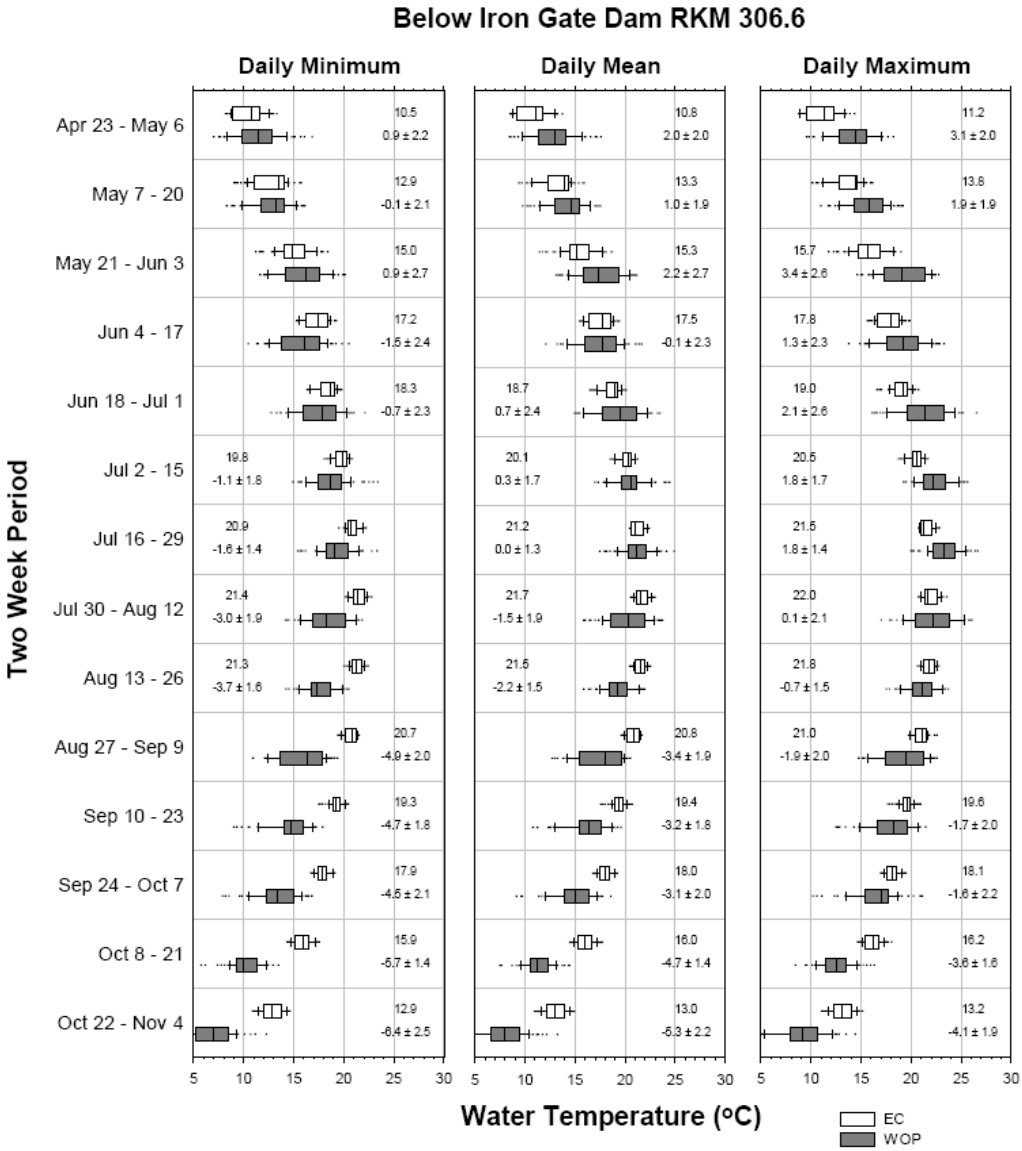
With an abundance of nutrients in the water, aquatic plants thrive in the Klamath River and the mainstem reservoirs (Campbell, 1999). Without Iron Gate and Copco No. 1 dams in place, planktonic algae densities would substantially decrease, allowing opportunistic attached algae and rooted vegetation to capitalize on the nutrient-rich waters within the river in areas with suitable substrate. The dense algae blooms that currently occur in Copco and Iron Gate in July and August often are dominated by the same nitrogen fixing algae that contributes to increased nitrogen in Upper Klamath Lake. Removal of the dams would reduce the seasonal nitrogen loading potential by algae and internal loading by anoxic sediments, thereby reducing nitrogen availability within the area and downstream. The greatest amount of nutrient uptake by attached algae or rooted vegetation would most likely occur close to the source of nutrient inputs, which without Copco or Iron Gate would be closer to Keno reservoir and nutrient uptake would continue through the project area and beyond.



[a] Line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers.

[b] Numbers adjacent to the box plots are the mean temperature under EC (top) and the mean difference (WOP minus EC) ± 1 SD (bottom).

Figure 3-55. Box plots[a] of 2-week summaries of modeled existing conditions and without project[b] daily minimum, mean, and maximum water temperatures from April to November for the years 2000 through 2004 below Copco 1 dam, predicted by PacifiCorp's Klamath River Water Quality Model. (Source: Dunsmoor and Huntington, 2006)



[a] Line inside box is median, box ends are 25th and 75th percentiles, whisker ends are 10th and 90th percentiles, dots are outliers.

[b] Numbers adjacent to the box plots are the mean temperature under EC (top) and the mean difference (WOP minus EC) ± 1 SD (bottom).

Figure 3-56. Box plots[a] of two week summaries of modeled existing conditions and without project[b] daily minimum, mean, and maximum water temperatures from April to November for the years 2000 through 2004 below Iron Gate dam, predicted by PacifiCorp's Klamath River Water Quality Model. (Source: Dunsmoor and Huntington, 2006)

Should *Cladophora* become established in formerly impounded river reaches at Copco and Iron Gate, as figure 3-44 suggests could occur, we expect it to thrive, given the high nutrient concentrations entering the river from the upper basin. This could have implications for anadromous fish restoration, discussed in section 3.3.3.2.5, *Anadromous Fish Restoration*. However, the nutrient dynamics in the Klamath River would be altered if one or more mainstem dams were to be removed, and predicting future

nutrient conditions and associated *Cladophora* colonization in the vicinity of the current Copco and Iron Gate dam sites would be difficult. Because the river would be free flowing for a longer portion of the reach, there would be ample opportunity for waters to be well-aerated from natural turbulence, dampening the current extremes in DO concentrations in the middle section of what is now Copco and Iron Gate reservoirs. When oxygen is present, phosphate typically is bound to sediment particulates, becoming unavailable for plant growth.

Removal of any dam increases the likelihood of increasing suspended sediment in the water column by mobilizing the sediment stored behind the dam, at least temporarily. The effective prediction of outcomes of dam removal in terms of downstream effects of mobilized sediments depends on reasonable estimates of the material to be removed, understanding of the geomorphic and hydrologic behavior of the channel, and accurate hydraulic assessment of the post-removal river flows (Heinz Center, 2002). Thus, site-specific information is a key element of predicting potential consequences of dam removal. Some site-specific information is available from a study conducted on behalf of PacifiCorp by Eilers and Gubala (2003), but the most comprehensive site specific studies directly related to potential dam removal were conducted on behalf of the California Coastal Conservancy by GEC (2006). Consequently, we rely extensively on the analysis reported by GEC (2006) because it represents the best available information, and the analysis was conducted using methods that are commonly used to predict responses of rivers to potential dam breaks or removals. We discuss both of these studies further in section 3.3.1, *Geology and Soils*.

GEC (2006) analyzed the potential effects of removal of the four lower mainstem project dams on water quality and aquatic habitat, based on site-specific sediment sampling. The results of that study indicate that the primary, fine-grained sediment in J.C. Boyle reservoir is sand (80 percent, based on one boring and four grab samples). Contaminants typically do not bind to sand and following mobilization, sand rapidly settles out of the water column. Consequently, there would not likely be substantive effects on downstream water quality associated with removal of this dam. The small size of Copco No. 2 reservoir would also not have a substantial bearing on downstream conditions with its removal. Therefore the focus of GEC's analysis was on water quality and habitat effects related to removal of Copco and Iron Gate dams. GEC concludes that the sediments within these two reservoirs are relatively free of contaminants and do not warrant removal and disposal at a secure landfill. Even though much of the sediment in Copco and Iron Gate reservoirs is clay and silt, and more subject to resuspension than larger particles, GEC concludes that allowing the relatively manageable sediment loads to erode and pass downstream is a viable option. Based on the information available to us, we concur with GEC's conclusion. We discuss geomorphological aspects of potential dam removals, which would also have a bearing on water quality, in section 3.3.1.2.6, *Development Decommissioning and Dam Removal*.

Mobilization of sediments stored behind project dams would pose the greatest risk to water quality in the form of increased total suspended sediments (TSS). GEC's review of other dam removals indicates that the duration of elevated TSS is a more important consideration than the level of TSS concentrations, and that durations can be controlled by drawdown rates and the sequence (or concurrent) drawdown of the reservoirs. GEC estimates that about 84 percent of the eroded sediment from dam removal would remain in suspension until it reaches the mouth of the river. The rate at which the reservoirs could be drawn down prior to deconstructing the actual dam would determine the duration of highly elevated TSS concentrations immediately downstream of Iron Gate dam (GEC, 2006).

GEC (2006) estimates that if Copco No. 1 dam is removed while Iron Gate dam is still in place, about 40 percent of the resuspended sediment from Copco reservoir would pass through Iron Gate reservoir to the downstream reaches of the Klamath River. Thus, GEC concludes that the trapping efficiency of Iron Gate reservoir many not be sufficient to eliminate potential water quality protection requirements associated with removing Copco No. 1 dam prior to removing Iron Gate dam. According to GEC, TSS levels downstream of Iron Gate dam would remain above 1,000 parts per million for about 120 days during the Copco reservoir drawdown, assuming a drawdown rate of 1 foot per day. GEC assumes

that with a sequential dam removal, the drawdown of Iron Gate reservoir and removal of Iron Gate dam would begin immediately after Copco No. 1 dam is removed. This would again increase TSS to over 1,000 parts per million for about 120 days, and TSS would exceed 3,000 parts per million for about 90 days. However, we conclude that adverse effects associated with extended periods of elevated TSS would be substantially reduced if Iron Gate dam should remain in place for one or more years following removal of the upstream dams. Habitat downstream of Iron Gate dam would be able to recover from the initial increased TSS levels during removal of upstream dams and because periods of elevated TSS would only be expected to occur for about 4 months, the timing of the sequential dam removal could be adjusted to correspond with periods when key lifestages of salmonids would be least affected.

Removal of Copco No. 1 and Iron Gate dams concurrently would substantially reduce the duration of elevated TSS. However, instantaneous TSS concentrations below Iron Gate could exceed 50,000 parts per million (GEC, 2006). Depending on the drawdown rate, sediment removal could take between 45 and 180 days at rates of 3 feet and 1 feet per day, respectively. Associated predicted TSS levels with a drawdown rate of 3 feet per day would exceed 20,000 parts per million for about 35 days and 3,000 parts per million for about 50 days immediately downstream of Iron Gate dam,. With a drawdown rate of 1 foot per day predicted, TSS would exceed 20,000 parts per million for about 20 days and 3,000 parts per million for about 130 days immediately downstream of Iron Gate dam, (GEC, 2006). We discuss the effects of sediments on spawning habitat within the mainstem Klamath below Iron Gate dam in section 3.3.3.2.5, *Anadromous Fish Restoration.*

Hazardous Substances

The Bureau of Land Management specified in its preliminary 4(e) conditions that PacifiCorp file a hazardous substances plan for oil and hazardous substance storage, spill prevention, and clean up with the Commission prior to planning, construction, or maintenance that may affect Bureau of Land Management-managed land. At least 90 days prior to filing the plan with the Commission, PacifiCorp would submit the plan to the Bureau of Land Management for review and approval. The plan would outline procedures for reporting and responding to releases of hazardous substances and make provisions for maintaining emergency response and HAZMAT cleanup equipment sufficient to contain any spill from the project.

The Bureau of Land Management also specified in its preliminary 4(e) conditions that PacifiCorp should semi-annually provide the Bureau of Land Management with information on the location of spill cleanup equipment on Bureau of Land Management-managed land and the location, type, and quantity of oil and hazardous substances stored in the project area. PacifiCorp would inform the Bureau of Land Management immediately as to the nature, time, date, location, and action taken for any spill affecting Bureau of Land Management-managed land.

PacifiCorp submitted alternative 4(e) conditions to the Bureau of Land Management (filed with the Commission on April 28, 2006). PacifiCorp's alternative 4(e) condition modifies the Bureau of Land Management condition by stating that it would implement and maintain spill prevention control and countermeasure plans at all project facilities in compliance with 40 CFR Part 112. PacifiCorp states that the plans would be made available to the Commission and the Bureau of Land Management as requested. Finally, PacifiCorp states that the scope of this condition would only include Bureau of Land Management lands within the project boundary.

PacifiCorp also provided an alternative 4(e) condition to semi-annually provide the Bureau of Land Management with information on the location of spill cleanup equipment on Bureau-managed land and the location, type, and quantity of oil and hazardous substances stored in the project area. PacifiCorp states that it would maintain spill clean-up equipment on Bureau of Land Management lands within the project boundary in accordance with the required spill prevention and cleanup plans. PacifiCorp proposes to submit annually a copy of its annual emergency and hazardous chemical inventory (Tier II form) to the

appropriate state jurisdictional agencies in accordance with federal regulations. PacifiCorp does not say that it would provide this Tier II form to the Bureau of Land Management. It agrees to notify the Bureau of Land Management of any spills on Bureau lands within the project boundary, but does not provide for notification if spills affect, but do not occur on, Bureau lands.

Our Analysis

In accordance with 40 CFR §112.1 of EPA's regulations, a hazardous substance plan (also referred to as a spill prevention control and countermeasure plan) is required to be in place for any facility where unburied storage capacity exceeds 1,320 gallons of oil or a single container has capacity in excess of 660 gallons. In addition to the onsite storage of lubricants and other oil products, transformers at the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate powerhouses are oil-cooled and would be of sufficient capacity to exceed the threshold to require a hazardous substances plan to be in place, independent of this relicensing procedure. This plan would provide a quick reference to procedures and notifications in case of oil spills and reduce the possibility of oil or other hazardous substances reaching the Klamath River if a spill occurs. A hazardous substances plan would minimize the amount of petroleum products that would enter project waters in the unlikely event of a spill. There is no evidence that PacifiCorp stores smaller quantities of oil than those that would trigger preparation of a hazardous substances plan or additional hazardous substances besides petroleum products within the existing or proposed project boundary. However, if such is the case, extending the hazardous substances plan to include smaller quantities of oil and other hazardous substances would reduce the risk of contamination of project lands and waters by these products and would reduce the extent of contamination should a spill occur. If hazardous substances not covered under PacifiCorp's existing hazardous substances plan should be needed prior to any planned construction or maintenance activities, we consider inclusion of a site specific addendum to PacifiCorp's existing plan to cover this construction or maintenance activity to be reasonable and consistent with documented Best Management Practices. For construction or modifications of existing project facilities, the site-specific hazardous substances plan addendum, with the base plan, could be submitted for approval as part of the final plan for the site.

We are not aware of any actions proposed by PacifiCorp as part of this relicensing proceeding that would entail new construction or maintenance that would not be addressed in a plan proposed by PacifiCorp or recommended by the staff. The type of construction or maintenance that would require a new plan for oil and hazardous substances storage and spill prevention and cleanup would typically require a licensee to file a request for a license amendment with the Commission. The need for such a new plan would be addressed in the license amendment proceeding.

PacifiCorp already reports information on the location of spill cleanup equipment and the location, type, and quantity of oil and hazardous substances stored in the project area to the appropriate state agencies on an annual basis. This report includes Bureau of Land Management managed lands within the project boundary. The Bureau of Land Management has not made its case why the existing annual reporting should be shortened to semi-annual reporting and why the existing reports provided to state agencies are not sufficient to document on-site hazardous material inventories. Coordinated efforts between the Bureau of Land Management and the state agencies would alleviate the need for PacifiCorp to prepare duplicative inventory and reporting information as specified by the Bureau of Land Management. Providing copies of the reports that PacifiCorp provides to state agencies to the Bureau of Land Management should not be burdensome and would keep the Bureau of Land Management informed regarding the location of project-related hazardous material storage sites and spill clean-up equipment.

In response to information filed since the issuance of the preliminary section 4(e) conditions, Bureau of Land Management's modified section 4(e) conditions, filed by Interior on January 30, 2007, no longer include provisions for PacifiCorp to file a hazardous substances plan or semi-annual inventories of spill clean-up equipment. Bureau of Land Management, in its discussion of its modified conditions,

anticipates that where specific actions may necessitate such plans and measures, the measures would be included as part of the site-specific plan for that activity. This is consistent with our analysis.

3.3.2.3 Cumulative Effects

Construction of the project dams resulted in areas of the river where the physical processes that control water quality have experienced a shift, as the processes in lakes are markedly different relative to the river environment. Although at times water quality meets applicable state water quality objectives (typically during the winter, high flow months) the water quality within some of the project impoundments (i.e., Keno, Copco, and Iron Gate reservoirs) has evolved to mimic highly productive lakes, which experience algal blooms and complex nutrient cycling and loading processes. Diversion of water for hydroelectric generation has substantially altered flow and temperature regimes in the bypassed reaches; however, under the existing hypereutrophic conditions, diversion of water from the J.C. Boyle bypassed reach has resulted in an improvement to that reach's water quality. Other actions throughout the upper Klamath River Basin that could cumulatively affect water quality include management plans and policies, land use practices, and changes in agricultural market conditions. We discuss below the potential effects of other activities not directly under the Commission's control that have a bearing on project water quantity and quality.

Implementation of the TMDL for Upper Klamath Lake and the subsequent reduction in phosphorous loading to the lake should, over time, improve water quality within the lake and in releases to the Link River, in addition to releases to the Klamath Irrigation Project through the A canal. Development of the TMDL for the Klamath River would build on the existing TMDL for Upper Klamath Lake and allocate acceptable nutrient loads to the Klamath River from point and non-point sources throughout the Upper Klamath Basin. Once loads have been established, NPDES permit holders and agricultural land owners would become eligible to apply for funding to implement measures to reduce the nutrient loads leaving their properties and entering the Klamath River. This program would provide benefits to water quality throughout the Klamath River over the anticipated term of a new license. The TMDL program relies on voluntary involvement for loads identified from non-point sources; therefore, nutrient load reductions to the allocated size may not be fully realized as farmers and ranchers choose between converting portions of their land to best management practices or maximizing their property's agricultural potential.

Reclamation's CIP would work to bring agencies and non-governmental organizations interested in protecting water quality and other affected resources together to develop policies and plans to alleviate the current stresses on water quality and aquatic resources. Currently the CIP is in its third draft and provides a framework of interagency collaboration to aid existing ecosystem restoration and water management efforts developed at the local level to advance more rapidly by providing resources, coordination, and communication. The CIP can also fund research to increase understanding of the Klamath River system and monitoring to evaluate progress toward program goals. Implementation of a final CIP would provide the framework to coordinate basin-wide restoration and monitoring efforts in a collective effort to improve water quality and other resources.

Reclamation must maintain certain lake elevations and river flows through implementation of the conditions specified in Biological Opinions issued by FWS and NMFS. At the same time, Reclamation must operate the Klamath Irrigation Project, which includes water in Upper Klamath Lake and releases to the Link River and A canal, consistent with its tribal trust obligations, contracts for the delivery of water throughout the Klamath Irrigation Project, and water supply to the Lower Klamath and Tule Lake National Wildlife refuges. As such, water availability for other purposes (e.g., seasonal high flow events, additional spillage) is limited and during dry years becomes a highly contested resource. Over time, the overall limitations on water availability and dynamic hydrographs contribute to conditions that result in a channel that becomes stable and prone to other undesirable consequences to water quality and aquatic

resources. The ability to store additional water at Long Lake is currently under study as a means to increase water availability throughout the Klamath River Basin.

Inflow to the Klamath Hydroelectric Project is largely the result of releases from Link River dam and withdrawals or return flows from the Klamath Irrigation Project. The limited active storage of the project reservoirs greatly limits the effects of project operations during flooding events or extremely dry periods along the middle and lower reaches of the Klamath River. Maintenance of the current water level regime within Keno reservoir would ensure the continued supply of water to and from the Klamath Irrigation Project. We discuss cumulative water quantity effects on aquatic and riparian habitat in section 3.3.1.3, *Geology and Soils*; and effects on aquatic biota in section 3.3.3.3, *Aquatic Resources*, and 3.3.5.3 *Threatened and Endangered Species*.

Water demands in other tributary watersheds to the Klamath River can put an additional strain on the resources that rely on the Klamath River. The California State Water Project controls releases from the Trinity River to the Klamath through diversions to the Central Valley, which, depending on the water year type, can have a substantial effect on flows in the lower Klamath River. Diversions of water result in reduced volume entering the Klamath River, exacerbating high temperatures, especially during low flow years, and further stressing anadromous fish. The headwaters of the Trinity are largely undeveloped resulting in good water quality that, before the California State Water Project, would help dilute the naturally high nutrient loads within the Klamath River and buffer temperature extremes. Demand for these tributary sources limits the ability of the natural system to provide protection to the resources that rely on it. Collaboration between interbasin water users (including transfers from the Klamath Basin to the Rogue River Basin to the north and the California State Water Project to the southeast) and diverters could lead to more effective management of flow releases to the Klamath River, which could provide relief from extreme temperatures. In addition, during non-dry years, collaboration may provide seasonal high type flow events to mobilize the substrate which could reduce attached algae distribution and may lower *C. shasta* infection rates among salmonids within the lower Klamath River.

The expiration of the 1956 contract between PacifiCorp and Reclamation which provided reduced electrical rates to Klamath Irrigation Project irrigators may result in changes in agricultural practices that change the amount of Klamath River water that is used for irrigation. Because much of the water initially used for irrigation is returned to the Klamath River, any reduction in irrigation water use would reduce the amount of nutrients and other agricultural byproducts entering the Klamath River during the summer growing season. Allowing fair market practices to determine resource allocation could lead to distribution patterns throughout the basin that could improve water quality as water users choose not to irrigate, change crops, or reduce farming efforts. On the other hand, a change to less expensive, less efficient irrigation practices (such as flood irrigation) may adversely affect water quality by increasing the amount of nutrients that are delivered to the river with agricultural return flows.

Extensive timber harvesting and conversion of land for resource extraction purposes (e.g., mining for gravel, gold, and other materials) throughout the watershed results in increased sediment and nutrient loads to the Klamath River. Increased sediment loading degrades water quality by increasing bedload and suspended solids in the water. As the solids settle, they create a shallower river channel susceptible to warming during months with the most daylight. During high flow events, previously settled sediments could become re-suspended, generating a deeper channel that would buffer the river from daily temperature swings. If the above-mentioned land types become reforested, the area would experience less direct runoff, increased potential groundwater contributions, and reduced pollutants. Effects would be dynamic and ongoing as land uses throughout the basin change due to numerous socioeconomic factors.

3.3.2.4 Unavoidable Adverse Effects

The project, as proposed, would continue to affect temperatures in the Klamath River. Implementation of strategic operations or facility modifications that use cool water stored in project

reservoirs, as discussed previously, could temporarily alleviate project effects on temperatures downstream of Iron Gate dam; however these effects would be limited to a few degrees Celsius and last from a few days to, at most, a couple of weeks. In addition, even with implementation of best management practices that may be developed as part of a project-wide water quality management plan, it is likely that algal blooms would continue to occur in project reservoirs, albeit at a smaller scale and less frequently, and some degree of project-related nutrient enrichment would occur in the Klamath River downstream of Iron Gate dam.

Removal of any project dam(s) as recommended by various stakeholders would expose sediment previously trapped behind project reservoirs to scour, increasing the turbidity of the water downstream of any dam that might be removed. The magnitude and duration of this effect would be related to the amount of sediment trapped behind the dam (see section 3.3.1, *Geology and Soils*), which dam(s) are removed, the removal methods, and any actions taken prior to breaching the dam (e.g., dredging). GEC (2006) concludes that depending on the drawdown rate used to evacuate the reservoirs, highly elevated suspended sediment concentrations could last between 40 and 120 days. The Conservancy-sponsored investigation on sediment characterization behind the project dams concludes that if eroded downstream, the sediment poses no contamination risk (GEC, 2006).

3.3.3 Aquatic Resources

3.3.3.1 Affected Environment

In this section we describe aquatic resources in the project vicinity including the conditions of aquatic habitats and populations of anadromous fish, resident fish, and macroinvertebrates that have the potential to be affected by relicensing. For anadromous fish, we include additional sections on hatchery operations, fish diseases, and harvest management. We provide additional information on the listing status, biology, and abundance of the federally listed coho salmon, Lost River sucker, and shortnose sucker in section 3.3.5, *Threatened and Endangered Species*. Table 3-37 lists the 64 fish species that are known to occur in the project area or are likely to occur downstream of the project. Fourteen of these species are or may be anadromous, and nine are considered to be occasional marine visitors. Native fish species constitute 20 out of the 38 fish species upstream of Iron Gate dam and 32 out of the 50 species considered likely to occur in downstream areas. Table 3-38 shows the seasonal timing of migration, spawning, incubation, and rearing life stages for important anadromous and resident fish species.

3.3.3.1.1 Aquatic Habitat Conditions

The facilities associated with the existing project are located over a 64-mile reach of the Klamath River, extending from Link River dam at RM 254.3 to Iron Gate dam at RM 190.1 (see figure 1-1). In our description of aquatic habitat conditions, we also include Upper Klamath Lake and its tributaries, upstream of the project, due to their potential influence on downstream water quality conditions and to support our evaluation of the potential for restoration of anadromous fish runs to upstream historic habitats. We also describe the mainstem Klamath River downstream of Iron Gate dam and its tributaries due to the potential effects of project operation on anadromous fish mainstem spawning and rearing habitats, and on the migration corridor extending downstream to the Klamath River estuary (the portion of the river that is tidally influenced). In section 2.1.1, *Existing Project Facilities*, of this EIS, table 2-1 lists the Klamath River's primary tributaries and mainstem reservoirs including their location by river mile.

Table 3-37. Fish species known to occur in the Klamath River and reservoirs upstream of Iron Gate dam and that are likely to occur downstream of Iron Gate dam. (Sources: PacifiCorp, 2004e; NAS, 2004; Moyle, 2002; Behnke, 1992)

Common Name	Scientific Name	Origin[b]	Status[c]	Temperature Preference[d]	Pollution Tolerance[e]	Present upstream of Iron Gate dam[f]	Present Downstream of Iron Gate dam[f]
Lampreys	**Petromyzontidae**						
Pit-Klamath brook lamprey	*Lampetra lethophaga*	N	N	Cool	I	R	--
Klamath River lamprey	*Lampetra similis*	N	N	Cool	I	R	R
Pacific lamprey	*Lampetra tridentata*	N	N, S	Cool	I	R	A
Miller Lake Lamprey	*Lampetra minima*	N	N	Cool	I	R	--
Sturgeons	**Acipenseridae**						
Green sturgeon	*Acipenser medirostris*	N	S	Cold	S	--	A
White sturgeon	*Acipenser transmontanus*	N	G	Cold	I	Stocked by ODFW in UKL[b]	A[g]
Herrings	**Clupeidae**						
American shad	*Alosa sapidissima*	I	G	Cool	I	--	A
Pacific herring	*Clupea pallasi*	N	G	n/a	n/a	--	O
Carps and Minnows	**Cyprinidae**						
Klamath Tui chub	*Siphateless bicolor bicolor*	N	N	Cool	T	R	R
Blue chub	*Gila coerulea*	N	N	Cool	T	R	R
Golden shiner	*Notemigonus crysoleucas*	I	N	Warm	T	R	R
Fathead minnow	*Pimephales promelas*	I	N	Warm	T	R	--
Klamath speckled dace	*Rhinichthys osculus*	N	N	Cool	I	R	R
Goldfish	*Carassius auratus*	I	N	Warm	T	R	R
Suckers	**Catostomidae**						
Klamath smallscale sucker	*Catostomus rimiculus*	N	N	Cool	I	R	R
Klamath largescale sucker	*Catostomus snyderi*	N	S	Cool	I	R	R
Shortnose sucker	*Chasmistes brevirostris*	N	E, S	Cool	S	R	R
Lost River sucker	*Deltistes luxatus*	N	E, S	Cool	I	R	--
Bullhead catfishes	**Ictaluridae**						
Yellow bullhead	*Ameiurus natalis*	I	G	Warm	T	R	R
Brown bullhead	*Ameiurus nebulosus*	I	G	Warm	T	R	R
Black bullhead	*Ameiurus melas*	I	G	Warm	T	R	--

Common Name	Scientific Name	Origin[b]	Status[c]	Temperature Preference[d]	Pollution Tolerance[e]	Present upstream of Iron Gate dam[f]	Present Downstream of Iron Gate dam[f]
Channel catfish	*Ictalurus punctatus*	I	G	Warm	T	R	--
Smelts	**Osmeridae**						
Surf smelt	*Hypomesus pretiosus*	N	G	Cold	S	--	O
Delta smelt	*Hypomesus transpacificus*	I	T,S	--	--	--	R
Longfin smelt	*Spirinchus thaleichtys*	N	G	Cool	I	--	A
Eulachon	*Thaleichthys pacificus*	N	G	Cool	I	--	A
Trouts and Salmon	**Salmonidae**						
Cutthroat trout	*Oncorhynchus clarki*	N	G	Cold	S	--	R, A
Pink salmon	*Oncorhynchus gorbuscha*	N	G	Cold	S	--	A[h]
Chum salmon	*Oncorhynchus keta*	N	G	Cold	S	--	A
Coho salmon	*Oncorhynchus kisutch*	N	G, T	Cold	S	--	A
Coastal Rainbow trout/Steelhead	*Oncorhynchus mykiss irideus*	N	G	Cold	S	--	R, A
Rainbow trout	*Oncorhynchus mykiss newberrii*	N	G, S	Cold	S	R	--
Sockeye salmon	*Oncorhynchus nerka*	N	G	Cold	S	--	O, A
Kokanee	*Oncorhynchus nerka kennerlyi*	I	G	Cold	S	--	R
Chinook salmon	*Oncorhynchus tshawytscha*	N	G	Cold	S	--	A
Brown trout	*Salmo trutta*	I	G	Cold	I	R	R, A
Brook trout	*Salvelinus fontinalis*	I	G	Cold	I	R	R
Arctic grayling	*Thymallus arcticus*	I	G	Cold	S	--	R
Bull trout[i]	*Salvelinus confluentus*	N	T	Cold	S	R	--
Silversides	**Atherinidae**						
Topsmelt	*Atherinops affinis*	N	G	n/a	n/a	--	O
Sticklebacks	**Gasterosteidae**						
Threespine stickleback	*Gasterosteus aculeatus*	N	N	Cool	T	--	R, A
Brook stickleback	*Culaea inconstans*	N	N	Cool	T	--	R
Sculpins	**Cottidae**						
Sharpnose sculpin	*Clinocottus acuticeps*	N	N	n/a	n/a	--	O
Coastrange sculpin	*Cottus aleuticus*	N	N	Cool	I	--	R
Prickly sculpin	*Cottus asper*	N	N	Cool	I	--	R
Marbled sculpin	*Cottus klamathensis*	N	N	Cool	I	R	R
Klamath Lake sculpin	*Cottus princeps*	N	N	Cold	I	R	--

Common Name	Scientific Name	Origin[b]	Status[c]	Temperature Preference[d]	Pollution Tolerance[e]	Present upstream of Iron Gate dam[f]	Present Downstream of Iron Gate dam[f]
Slender sculpin	*Cottus tenuis*	N	N,S	Cool	I	R	--
Pacific staghorn sculpin	*Leptocottus armatus*	N	N	Cold	I	--	R, O
Sunfishes	**Centrarchidae**						
Sacramento perch	*Archoplites interruptus*	I	G	Warm	T	R	R
Green sunfish	*Lepomis cyanellus*	I	G	Warm	T	R	R
Pumpkinseed	*Lepomis gibbosus*	I	G	Cool	T	R	R
Bluegill	*Lepomis macrochirus*	I	G	Warm	T	R	R
Largemouth bass	*Micropterus salmoides*	I	G	Warm	T	R	R
Smallmouth bass	*Micropterus dolomieu*	I	G	Warm	T	--	R
Spotted bass	*Micropterus punctulatus*	I	G	Warm	T	--	R
White crappie	*Pomoxis annularis*	I	G	Warm	T	R	--
Black crappie	*Pomoxis nigromaculatus*	I	G	Warm	T	R	--
Perches	**Percidae**						
Yellow perch	*Perca flavescens*	I	G	Cool	I	R	R
Surfperches	**Embiotocidae**						
Shiner perch	*Cymatogaster aggregata*	N	N	Cold	S	--	O
Gobies	**Gobiidae**						
Arrow goby	*Clevelandia ios*	N	N	n/a	n/a	--	O
Righteye Flounders	**Pleuronectidae**						
Starry flounder	*Platichthys stellatus*	N	G	Cold	S	--	O

Notes: -- None collected, n/a not available.

[a] Species upstream of Iron Gate dam from city of Klamath Falls (1986) and PacifiCorp (2000). Species downstream of Iron Gate dam based on Moyle (1976).

[b] N = native, I = introduced; ODFW = Oregon Fish & Wildlife; UKL = Upper Klamath Lake.

[c] N = nongame, G = game, E = federally listed as endangered, T = federally listed as threatened, S = federal or state sensitive species or species of concern.

[d] From Zaroban et al. (1999).

[e] T = tolerant, I = intermediate, S = sensitive. From Zaroban et al. (1999).

[f] R = resident, A = anadromous, O = occasional marine visitor.

[g] NAS (2004) indicates that pink salmon are extinct in the Klamath River Basin.

[h] NAS (2004) notes that white sturgeon may migrate into the Klamath River but may not spawn there.

[i] Bull trout in the Klamath River Basin occur in the headwaters of the four tributaries to the Sprague River, four tributaries to the Sycan River, and two tributaries to Upper Klamath Lake (NAS, 2004).

Table 3-38. Estimated lifestage periodicity of key fish species occurring in the Klamath River.[a] (Source: PacifiCorp, 2004e, FWS, 1998; Trihey & Associates., 1996; NAS, 2004; Scheiff et al., 1991)

Species/Life Stage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Spring Chinook Salmon												
Adult migration	4	4	2						4	4	4	4
Adult spawning			**4**	**2**								
Incubation			4	4	**4**	**4**	**4**	**4**	**4**	4	2	
Fry emergence						4	4	**4**	**4**	**4**	4	
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration							2	4	4	4	**4**	4
Fall Chinook Salmon												
Adult migration		4	**4**	**4**								
Adult spawning				**4**	2							
Incubation				4	4	4	4	4	4			
Fry emergence							4	**4**	**4**	**4**		
Rearing							4	**4**	**4**	**4**	**4**	**2**
Juv. outmigration	**4**	4	4	4	2					4	**4**	**4**
Coho Salmon												
Adult migration				4	**4**	**4**						
Adult spawning						**4**	2					
Incubation						4	4	4	4			
Fry emergence								**4**	**4**	**2**		
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration	4							4	**4**	**4**	4	4
Steelhead Fall/Winter[b]												
Adult migration			4	4	4							
Adult spawning						4	4	4	**4**	4		
Incubation						4	4	4	4	4		
Fry emergence									4	4	**4**	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration	2								4	4	4	4

Species/Life Stage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Rainbow Trout												
Adult migration				4	4			2	**4**	**4**	2	
Adult spawning								2	4	4	2	
Incubation									4	4	4	4
Fry emergence	2									4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	
Juv. emigration[c]	4	4	4	4						4	4	4
Pacific Lamprey												
Adult migration	2	2	2			4	4	4	4	4	4	4
Adult spawning	2								2	4	4	4
Incubation	4								2	4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration	4	4	4	4	4	4	4	4	4	4	4	4
Shortnose and Lost River Suckers												
Adult migration								2	4	4	2	
Adult spawning									4	4	4	
Incubation									4	4	4	2
Larval emergence										4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4

[a] Numbers shown in table represent duration in weeks, numbers shown in bold indicate peaks in use or occurrence.

[b] FWS (1998) reports that small runs of summer and fall-run steelhead also occur, and that adult steelhead may migrate into the Klamath River throughout the year.

[c] The resident trout juvenile emigration indicates when fish are leaving their natal streams and entering the mainstem Klamath River.

Upper Klamath Lake and its Tributaries

Upper Klamath Lake and its tributaries contain a large amount of habitat that historically produced anadromous fish. The lake currently supports populations of two species of suckers that are federally listed as endangered (the Lost River and shortnose suckers), and a fishery for trophy-sized rainbow trout.[63]

Upper Klamath Lake is a very large, shallow, and nutrient-rich lake (NAS, 2004). When Upper Klamath Lake is at its normal maximum level (elevation 4,143 feet), it has a surface area of about 67,000 acres, a volume of 603,000 acre-feet, and a mean depth of only 9 feet, although there are substantial areas where depths exceed 20 feet. The lake has several large marshes at its margins, although approximately 40,000 acres of the marshland surrounding the lake have been drained and converted to agricultural production. The remaining marshes are strongly connected to the lake at high water and are progressively less connected at lower water levels down to about 4,139 feet, where they become isolated from the lake.

Before Link River dam was constructed in 1921, the water level of Upper Klamath Lake fluctuated within a relatively narrow range of about 3 feet (NAS, 2004). When that dam was constructed, the natural rock dam at the outlet of Upper Klamath Lake was removed so that the storage potential of the lake could be used to better support irrigated agriculture. Since 1921, lake levels have varied over a range of about 6 feet, and drawdown of about 3 feet from the original minimum water level has occurred in years of severe water shortages. Since about 1992, Reclamation has maintained higher lake levels developed in consultation with FWS to protect the federally listed Lost River and shortnose suckers (NAS, 2004). The lake levels identified in Reclamation's current operation plan are managed in accordance with FWS's most recent BiOp (FWS, 2002a) on Reclamation's 10-year operating plan[64] (Reclamation, 2002). As described in section 3.3.2, *Water Resources*, lake levels and irrigation diversions are also managed to meet seasonal minimum flows downstream of Iron Gate dam to protect the federally listed coho salmon in accordance with NMFS' BiOp (NMFS, 2002) on Reclamation's 10-year operating plan.

Poor water quality in Upper Klamath Lake has been implicated in the mass mortality of federally listed suckers, and may suppress their growth, reproductive success, and resistance to disease or parasitism. Potential agents of stress and death include high pH, high concentrations of ammonia, and low DO (FWS, 2002a). Extremes in these variables are caused by dense populations of phytoplankton (primarily the nitrogen-fixing blue-green algae *Aphanizomenon flos-aquae*), especially in the last half of the growing season (see discussion under *Nutrients* in section 3.3.2.1.2, *Water Quality*). Despite the occurrence of poor water quality conditions, Upper Klamath Lake supports a fishery for large rainbow trout that consistently produces trout in excess of 10 pounds (Messmer and Smith, 2002). Oregon Fish & Wildlife manages the trout fishery in Upper Klamath Lake, its major tributaries, and in the Klamath River

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[63]Upper Klamath redband rainbow trout is the subspecies of rainbow trout that is native to the upper Klamath River Basin. Coastal rainbow trout may have been the predominant subspecies in most areas downstream of Upper Klamath Lake, especially in areas that were accessible to anadromous steelhead downstream of Iron Gate dam. Since construction of Copco dam and Iron Gate dam, however, upstream of Iron Gate dam resident trout are considered redband trout, and downstream of Iron Gate dam resident trout are considered coastal rainbow trout (Behnke, 1992). Because some degree of genetic mixing is likely, we refer to the resident form as rainbow trout and the anadromous form as steelhead.

[64]Based on the March 26, 2006, ruling by the U.S. Ninth Circuit Court of Appeals, until the new consultation for the Klamath Irrigation Project is completed and reviewed by the U.S. Ninth Circuit Court, Reclamation is to limit irrigation deliveries if they would cause water flows in the Klamath River at Iron Gate dam to fall below Phase III flow levels specified in the 2002 NMFS BiOp.

downstream to the California state line (including the Keno and J.C. Boyle reservoirs) for natural production; no hatchery fish are stocked in these waters (Oregon Fish & Wildlife, 1997).

Section 3.3.3.1.2, *Anadromous Fish Species,* summarizes available information on historic use of Upper Klamath Lake and its tributaries by anadromous fish, and section 3.3.5, *Threatened and Endangered Species*, provides information on the biology and status of the federally listed Lost River sucker, shortnose sucker, and coho salmon.

Reclamation A Canal

The headworks of the A canal, which is the primary diversion point on Upper Klamath Lake for Reclamation's Klamath Irrigation Project, is located approximately 0.3 mile upstream of Link River dam. The A canal is capable of diverting up to 1,150 cfs of water during the peak of the irrigation season. The canal was equipped with fish screens in 2003 to protect the federally listed sucker species from entrainment. The fish screens include a primary pumped bypass that returns fish to Upper Klamath Lake and a secondary gravity flow bypass that can be used to route fish to the Link River immediately below Link River dam. The secondary bypass was included to provide managers with the flexibility to bypass fish to the Link River when adverse water quality conditions exist in Upper Klamath Lake near the outlet of the primary bypass.

Link River Dam

Link River dam, which Reclamation owns, is located at RM 254.3 (see figure 2-2). The dam is 16 feet high and includes a fish ladder, which was rebuilt in 2005 to improve upstream passage for federally listed sucker species. This ladder would also facilitate upstream passage of salmonids from Link River to Upper Klamath Lake. Intake gates on each side of the dam regulate flow into the canals that lead to East Side and West Side developments, which PacifiCorp proposes to decommission.

Link River

The 1.2-mile-long segment of the Klamath River that extends from Link River dam to Keno reservoir is commonly known as the Link River (see figure 2-2). The streambed in this section of the river is mostly bedrock, and at lower flows the river breaks into smaller braided channels. Reclamation manages flows that are released from Upper Klamath Lake into the Link River to meet flow requirements downstream of Iron Gate dam as specified in the NMFS 2002 BiOp (see table 3-11 in section 3.3.2.1.1, *Water Quantity*); these flows are designed to protect coho salmon in the lower Klamath River (Reclamation, 2002). Historically, up to 1,450 cfs of the flow released to Link River passed through the East Side and West Side development powerhouses, rather than being released at Link River dam. The amount of water that must be released into the Link River to meet the required flows below Iron Gate dam is affected by irrigation diversions and return flows and accretions from springs and tributaries between the Link River and Iron Gate dam. These accretion flows typically amount to about 300 to 500 cfs during low precipitation periods in the summer and fall.

In addition to the flow releases that are required to meet minimum flows downstream of Iron Gate dam, PacifiCorp has an agreement with Oregon Fish & Wildlife to maintain an instantaneous minimum flow of 90 cfs downstream of Link River dam. This minimum flow is increased to 250 cfs from July 27 through October 17 to comply with a requirement of the 2002 FWS BiOp to provide this flow when water quality conditions are adverse. Ramping rates below Link River dam that were developed in consultation with Oregon Fish & Wildlife during the 1980s limit the downramping rate to 20 cfs per 5 minutes when flows are between 0 and 300 cfs; 50 cfs per 30 minutes when flows are between 300 and 500 cfs; and 100 cfs per 30 minutes when flows are between 500 and 1,500 cfs.

Water quality conditions in Link River are similar to those that occur in Upper Klamath Lake, and include periods of high water temperatures, low DO levels, and high pH levels (see section 3.3.2.1.2,

Water Quality). Fish populations in the Link River are limited primarily to species that are able to tolerate these poor water quality conditions. Fisheries sampling conducted by PacifiCorp in 2001 and 2002 indicates that the fish population in this reach is dominated by blue chub, tui chub, and fathead minnows (table 3-39). A small number of Lost River suckers were collected in the spring of 2002, and none were collected in the other three sampling periods. Shortnose suckers were collected in both years, and they were the third most abundant species collected in the spring of 2002.

Table 3-39. Summary of fishery sampling conducted in the Link River using electrofishing techniques. (Source: PacifiCorp, 2004e, as modified by staff)

	Catch Per Unit Effort (fish per hour)			
Species	**2001 Backpack Electrofishing**	**2002 Backpack Electrofishing**	**2002 Spring Boat Electrofishing**	**2002 Summer Boat Electrofishing**
Rainbow trout	--	2.4	9.1	--
Blue chub	479.5	116.6	182.3	1361.7
Tui chub	112.5	132.5	437.5	466.3
Speckled dace	278.1	26.3	--	--
Sculpin spp.	35.8	123.8	--	--
Shortnose sucker	18.5	0.8	109.4	--
Lost River sucker	--	--	9.1	--
Klamath sucker spp.	--	--	18.2	18.7
Largemouth bass	--	0.8	--	--
Bluegill	1.2	--	--	--
Fathead minnow	608.0	175.6	--	56.0
Yellow perch	1.2	0.8	--	--
Unknown	--	47.1	--	--

Keno Reservoir

Keno reservoir is narrow and riverine in character, and is confined within a diked channel that was once part of Lower Klamath Lake. The reservoir is 20.1 miles long, has a surface area of 2,475 acres, an average depth of 7.5 feet and a maximum depth of 20 feet, and a total storage capacity of 18,500 acre-feet. Water levels in Keno reservoir are normally maintained within 0.5 foot of elevation 4,085.5 feet, during the irrigation season, although the reservoir may be drawn down by another 2 feet for 2 to 3 days in April or May to allow irrigators to conduct maintenance on pumps and canals that draw water from the reservoir (see table 3-12 in section 3.3.2.1.1, *Water Quantity*).

As described in section 3.3.2.1.2, W*ater Quality*, water quality conditions in Keno reservoir are heavily influenced by the high nutrient content of inflowing water from Upper Klamath Lake, but they are exacerbated by wastewater effluent from the city of Klamath Falls, Reclamation irrigation return water, and accumulated wood waste from lumber mill operations. Summer water quality is generally poor with heavy algae growth, high temperatures (> than 20°C) and pH (an average pH of 8.2 with a peak pH of 9.4 standard units), and low DO (4.5 to8.8 mg/L). Respiration demands from abundant algal populations combined with decomposition of organic matter (biological oxygen demand) can result in near-complete anoxia during certain time periods, and fish kills are sometimes observed in and downstream of Keno reservoir, as they are in the upstream Upper Klamath Lake (see previous description of sucker die-offs, from FWS, 2002a).

Sampling conducted by PacifiCorp in 2001 and 2002 indicates that fish populations in Keno reservoir are very similar to those in the Link River, and are dominated by the same pollution-tolerant species: blue chub, tui chub, and fathead minnows (table 3-40). Small numbers of the endangered shortnose and Lost River suckers were collected in Keno reservoir in both 2001 and 2002.

Table 3-40. Keno reservoir electrofishing catch during fall 2001, and spring, summer and fall 2002. (Source: PacifiCorp, 2004e)

Species	Fall 2001			Spring 2002			Summer 2002			Fall 2002			Total		
	Number Collected	Percent of Total (%)	CPUE[a]	Number Collected	Percent of Total (%)	CPUE[a]	Number Collected	Percent of Total (%)	CPUE[a]	Number Collected	Percent of Total (%)	CPUE[a]	Number Collected	Percent of Total (%)	CPUE[a]
Fathead minnow	68	12.1	48.9	79	16.8	42.9	2,657	70.4	6,480.5	261	37.6	121.4	3,065	55.7	529.4
Blue chub	241	42.7	173.4	68	14.5	37.0	717	19.0	1,748.8	255	36.8	118.6	1,281	23.3	221.3
Tui chub	229	40.6	164.7	310	65.9	168.5	292	7.7	712.2	73	10.5	33.9	904	16.4	156.2
Yellow perch	5	0.9	3.6	3	0.6	1.6	16	0.4	39.0	8	1.2	3.7	32	0.6	5.5
Klamath largescale sucker	0	0	0	4	0.9	2.2	0	0	0	26	3.8	12.1	30	0.5	5.2
Shortnose sucker	15	2.6	10.8	4	0.9	2.2	0	0	0	6	0.9	2.8	25	0.5	4.3
Largemouth bass	3	0.5	2.2	0	0	0	0	0	0	4	0.6	1.9	7	0.1	1.2
Sacramento perch	0	0	0	0	0	0	1	<0.1	2.4	5	0.7	2.3	6	0.1	1.1
Sucker spp.	0	0	0	0	0	0	0	0	0	4	0.6	1.9	4	0.1	0.7
Pumpkinseed	1	0.2	0.7	0	0	0	1	<0.1	2.4	1	0.1	0.5	3	0.1	0.5
Sculpin spp.	0	0	0	0	0	0	1	<0.1	2.4	2	0.3	0.9	3	0.1	0.5
Klamath smallscale sucker	0	0	0	0	0	0	0	0	0	3	0.4	1.4	3	0.1	0.5
Bluegill	0	0	0	0	0	0	1	<0.1	2.4	1	0.1	0.5	2	<0.1	0.3
Lost River sucker	1	0.2	0.7	0	0	0	0	0	0	1	0.1	0.5	2	<0.1	0.3
Klamath speckled dace	0	0	0	0	0	0	2	<0.1	4.8	0	0	0	2	<0.1	0.3
Sucker (hybrid)	1	0.2	0.7	1	0.2	0.5	0	0	0	0	0	0	2	<0.1	0.3
Unidentified	0	0	0	1	0.2	0.5	87	2.3	212.2	44	6.3	20.4	132	2.4	22.8
Total	**564**	**100.0**	**405.7**	**470**	**100.0**	**255.4**	**3,775**	**100.0**	**9,207.3**	**694**	**100.0**	**322.8**	**5,503**	**100.0**	**950.4**

[a] CPUE — catch per unit of effort.

Keno Dam

Keno dam is equipped with a 24-pool weir and orifice type fish ladder, which rises 19 feet over a distance of 350 feet, designed to pass trout and other resident fish species. PacifiCorp has an agreement with Oregon Fish & Wildlife to release a minimum flow of 200 cfs at the dam per article 58 of its existing license. Similar to Link River dam, the average daily flow released from Keno dam generally follows the instream flow requirements downstream of Iron Gate dam, less anticipated accretion flows. Hourly flows released from Keno dam are affected by the rate of irrigation return flows delivered via the Klamath Straits drain and the Lost River diversion channel, which can vary by about 775 cfs over a 24-hour period.

Keno Reach

Downstream of Keno dam, the Klamath River flows freely for 4.7 miles until it enters J.C. Boyle reservoir (see figure 2-3). This section runs through a canyon area with a relatively high gradient of 50 feet/mile (1 percent) (PacifiCorp, 2000). The channel is generally broad, with rapids, riffles, and pocket water among rubble and boulders. Although summer water temperatures in the Keno reach are generally warmer than optimum for trout (the 7-day mean maximum daily water temperature in the reach can rise as high as 25°C), turbulence maintains DO levels that support a rainbow trout fishery. Like the rest of the Klamath River within Oregon, Oregon Fish & Wildlife manages the trout fishery for natural production with a daily bag limit of one fish per day. The fishery in the Keno reach is closed from June 15 through September 30, the warmest part of the year, when trout are subject to stress from high water temperatures.

Fisheries sampling conducted by PacifiCorp in 2001 and 2002 indicates that the fish population in the Keno reach is dominated by marbled sculpin, fathead minnows, blue chub, speckled dace, and tui chub (table 3-41). Rainbow trout were consistently collected, but in relatively small numbers. Of the federally listed sucker species, only the Lost River sucker was represented, and it was only collected in the lower part of the reach in 1 out of 2 years that were sampled. Creel surveys conducted by Oregon Fish & Wildlife between 1979 and 1982 and hook and line sampling conducted by PacifiCorp in 2002 both indicate that large rainbow trout are more common in the Keno reach than they are in the downstream J.C. Boyle bypassed and peaking reaches. In both data sets, about 25 percent of the trout collected in the Keno reach exceeded 15 inches in length, while fish of this size were rarely observed in the downstream reaches (PacifiCorp, 2004e).

Table 3-41. Summary of fishery sampling conducted in the Keno reach using backpack electrofishing techniques. (Source: PacifiCorp, 2004e, as modified by staff)

	Catch Per Unit Effort (fish per hour)		
Species	**2001[a] Lower reach RM 229 to 231.5**	**2002[b] Lower reach RM 229 to 231.5**	**2002[b] Upper reach RM 231.5 to 233**
Rainbow trout	3.0	3.0	69.7
Blue chub	184.0	222.3	10.4
Tui chub	120.0	142.5	21.4
Speckled dace	--	165.7	204.1
Marbled sculpin	264.0	469.8	93.8
Lamprey	--	--	0.5
Lost River sucker	--	1.0	--
Klamath suckers	16.0	--	--
Bluegill	--	1.0	--
Pumpkinseed	--	--	0.5
Fathead minnow	216.0	231.4	40.1
Unknown	--	99.0	11.0

[a] Sampling was conducted in the fall only.
[b] Average of spring, summer and fall sampling.

J.C. Boyle Reservoir

The upstream half of the J.C. Boyle reservoir is shallow and is surrounded by a low-gradient, gently sloping shoreline, while the reservoir deepens in the lower half, where the canyon narrows again. The upper end of the reservoir contains a large amount of macrophytes during the summer and several fairly large shoreline wetland areas. Like the upstream Keno reservoir, water quality is often degraded, particularly during the summer. The reservoir is 3.6 miles long, has a surface area of 420 acres, an average depth of 8.3 feet, a maximum depth of 40 feet, and a total storage capacity of 3,495 acre-feet. Water levels in J.C. Boyle reservoir are normally maintained within 5.5 feet of full pool, and daily fluctuations due to peaking operation of the J.C. Boyle development are typically between 1 and 2 feet.

PacifiCorp contracted Oregon State University to sample J.C. Boyle, Copco, and Iron Gate reservoirs to assess the abundance and distribution of endangered suckers in the project reservoirs during 1998 and 1999. The sampling effort also provided information on the abundance of other fish species that occur in these reservoirs. Sampling conducted in the J.C. Boyle reservoir indicates that the fish community is dominated by chub species, fathead minnows, and bullheads (table 3-42). A total of 64 rainbow trout were collected over the 2 years representing 0.9 percent of all fish collected. Of the two federally listed sucker species, a total of 44 shortnose suckers and 2 Lost River suckers were collected. Another 415 unidentified suckers were also collected, as were 187 Klamath smallscale suckers and 1 Klamath largescale sucker. The investigators reported that this was the only one of the three project reservoirs sampled where they collected all three life stages of suckers (larvae, juvenile, and adult), and they speculated that the reservoir may be seeded with larval suckers emigrating from Upper Klamath Lake (Desjardins and Markle, 2000).

Spencer Creek enters J.C. Boyle reservoir and provides spawning habitat for rainbow trout in the Keno reach, and to a lesser extent, the J.C. Boyle bypassed and peaking reaches. Counts of trout passing the fish ladder at J.C. Boyle dam in 1959, the year after J.C. Boyle dam and fish ladder were constructed, showed an estimated upstream passage of 5,529 rainbow trout. These fish were apparently moving upstream to spawn in Spencer Creek or in potential spawning habitat near the mouth of Spencer Creek that was inundated by the reservoir. More recent data indicate that the number of fish ascending the ladder has declined. An estimated 3,882 trout ascended the ladder in 1961, and 2,295 trout ascended the ladder in 1962. The next period when passage was monitored was from 1988 through 1991. Rainbow trout passage in these 4 years was 507, 588, 412, and 70 fish, respectively. Flows contributed from Spencer Creek normally range between 20 and 200 cfs.

J.C. Boyle Dam

PacifiCorp constructed J.C. Boyle dam, which is 68 feet high, in 1958 (see figure 2-3). The dam is equipped with a 569-foot-long pool and weir fishway, with 63 pools, which operates over a gross head range of approximately 55 to 60 feet. The dam diverts flow into a 2.56-mile-long flow line (combination of steel flow line, canal, tunnel, and penstock) to a powerhouse, creating a 4.3-mile-long bypassed reach. The intake to the flow line at J.C. Boyle dam is equipped with vertical traveling screens and a fish bypass pipe that delivers screened fish and debris along with a 20 cfs bypass flow to the base of the dam. The existing fish screens do not meet current agency velocity criteria.

Table 3-42. Number of fish collected by gear type during 1998 and 1999 in the J.C. Boyle reservoir.[a] (Source: PacifiCorp, 2004e)

Species	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Lamprey spp.	2	0	4	3	0	0	0	0	0	0	0	1	6	4
Tui chub	123	166	133	70	10	2	0	2	0	0	0	0	266	240
Blue chub	39	30	25	87	8	5	2	0	0	0	0	0	74	122
Chub spp.	0	0	0	402	13	633	618	34	35	36	0	0	666	1,105
Golden shiner	0	0	0	0	0	1	0	1	0	3	0	0	0	5
Fathead minnow	0	0	5	280	65	190	168	14	0	198	0	0	238	682
Klamath speckled dace	0	0	0	61	8	62	11	28	0	349	0	0	19	500
Klamath smallscale sucker	62	97	2	26	0	0	0	0	0	0	0	0	64	123
Klamath largescale sucker	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Shortnose sucker	5	13	0	31	0	0	0	0	0	0	0	0	5	44
Lost River sucker	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Sucker spp.[b]	4	2	0	8	75	105	49	34	0	126	5	7	133	282
Bullhead spp.	167	207	88	290	7	11	1	0	0	0	0	0	263	508
Rainbow trout	33	24	1	3	0	0	0	0	0	0	2	1	36	28
Sculpin spp.	0	0	0	0	0	25	0	7	0	0	0	0	0	32
Sacramento perch	8	4	178	31	0	0	0	0	0	0	0	0	186	35
Pumpkinseed	1	1	415	59	5	89	0	2	0	0	0	0	421	151
Bluegill	0	0	0	0	2	0	0	0	0	0	0	0	2	0
Largemouth bass	9	4	0	0	17	65	0	0	0	0	0	0	26	69
Sunfish spp.	0	0	14	0	242	0	127	0	19	0	0	0	402	0
Crappie spp.	34	6	128	27	2	1	0	0	0	0	0	0	164	34
Yellow perch	35	4	0	5	0	1	1	1	0	0	0	0	36	11
Unidentified	0	0	0	0	0	0	0	27	0	32	3	11	3	70
Total Individuals	523	560	993	1,383	454	1,190	977	150	54	744	10	20	3,011	4,047
Total Taxa	14	13	11	15	12	13	8	10	2	5	3	4	20	20
Sampling Effort														
Sets/Pulls	16	8	10	13	17	18	19	17	7	10	7	16		
Hours	173	119	118	197	—	—	—	—	—	—	25	79		

[a] Target lifestyles codes: A= adult, J=juvenile, L=Larvae.

[b] Data presented in Desjardins and Markle (2000) indicate that 48 percent of the unidentified sucker spp. collected in J.C. Boyle reservoir in 1998 and 23 percent of the unidentified sucker spp. collected in 1999 were juveniles. The remaining 52 percent of the unidentified sucker spp. collected in 1998 and 77 percent of the unidentified sucker spp. collected in 1999 were larvae.

J.C. Boyle Bypassed Reach

The J.C. Boyle bypassed reach is 4.3 miles long, extending from the dam to the J.C. Boyle powerhouse. This reach of the Klamath River has a relatively steep gradient of about 2 percent. The river channel is approximately 100 feet wide, and consists primarily of rapids, runs, and pools among large boulders with some large cobbles interspersed. Gravel is scarce, in part because recruitment from upstream areas is blocked by the presence of J.C. Boyle dam. Although erosion caused by operation of the emergency overflow spillway contributed a large volume of sediment to the lower third of the reach, as noted previously in section 3.3.1, *Geology and Soils*, this section of the river also has substantial capacity to transport sediments due to its high stream gradient (2.3 percent) in the vicinity of the emergency overflow spillway. When spill from the dam is substantial, habitat in the bypassed reach consists of a series of rapids and fast runs.

PacifiCorp releases a 100 cfs minimum flow at the dam into the J.C. Boyle bypassed reach. An additional 220 to 250 cfs of spring flow accrues in the bypassed reach, beginning about 0.5 mile downstream from the dam. The existing license limits the rate of upramping and downramping in the bypassed reach to 9 inches per hour.

Fisheries sampling conducted by PacifiCorp in 2001 and 2002 indicates that the fish population in the J.C. Boyle bypassed reach is dominated by rainbow trout, speckled dace, and marbled sculpin (table 3-43). The shortnose sucker was the least common of the five species that were collected in 2001, and none were collected in 2002. No Lost River suckers were collected in either year.

Table 3-43. Fishery sampling conducted in the J.C. Boyle bypassed reach using backpack electrofishing techniques. (Source: PacifiCorp, 2004e, as modified by staff)

	Catch Per Unit Effort (fish per hour)		
Species	**2001[a] (entire reach)**	**2002[b] upper 1 mile (above springs)**	**2002[b] lower 3 miles (below springs)**
Rainbow trout	112	12.2	22.6
Blue chub	--	4.9	0.8
Tui chub	16	5.5	0.4
Speckled dace	24	38.3	1.5
Marbled sculpin	16	17.0	31.1
Lamprey	--	0.6	--
Shortnose sucker	8	--	--
Largemouth bass	--	1.2	0.4
Sacramento perch	--	0.6	--
Bluegill	--	7.9	--
Pumpkinseed	--	7.9	0.8
Black crappie	--	0.6	--
White crappie	--	0.6	--
Fathead minnow	--	--	0.8
Bullhead spp.	--	12.2	--

-- none collected
[a] Sampling was conducted in the fall only.
[b] Average of spring, summer and fall sampling.

J.C. Boyle Peaking Reach

The J.C. Boyle peaking reach is 17.3 miles long, extending from the J.C. Boyle powerhouse at RM 220.4 to the upper end of Copco reservoir (see figures 2-3 and 2-4). The upstream 11.1 miles of this reach are in Oregon, and this segment has been federally designated as a Wild and Scenic River (discussed further in section 3.3.6, *Recreational Resources*, and section 3.3.7, *Land Use and Aesthetic*

Resources). The downstream 6.2 miles are in California, and the segment is designated by Cal Fish & Game as a Wild Trout Area. Both sections are managed for wild trout. The Oregon reach has not been stocked with hatchery trout since 1978, and the California reach has not been stocked since 1974.

In the Oregon portion of the reach, habitat includes cascades, deep and shallow rapids, runs, riffles, and occasional deep pools. Substrate is heavily armored and consists primarily of boulders and large cobbles, with a few small pockets of gravel behind boulders. The California segment of the peaking reach is wider and lower in gradient, and contains more riffles and runs, and infrequently exhibits pools and quiet water. Substrate is primarily bedrock, boulders, and cobbles, with a few gravel pockets behind boulders. The California portion exhibits good riparian and instream cover including boulders, rooted aquatic plants, and undercut banks.

Stream flows in the reach are affected by peaking operation of the J.C. Boyle development. Under current operations, water is typically stored at night and flows during the day ramp up to either one unit operation (up to 1,500 cfs) or two unit operation (up to 3,000 cfs, but typically 2,750 cfs). When generation ceases at night, flow at the powerhouse consists of the flow that is released from J.C. Boyle dam into the bypassed reach (with the exception of spill periods, this is normally the 100 cfs minimum flow), plus the 220 to 250 cfs of spring flow that accrues in the bypassed reach. The current licensed ramping rate is 9 inches per hour for both upramping and downramping.

Fisheries sampling conducted by PacifiCorp in 2001 and 2002 indicates that the fish population in the J.C. Boyle peaking reach is comprised primarily of speckled dace, marbled sculpin, and rainbow trout (table 3-44). Shortnose sucker was the least common of the four species that were collected in 2001, and none were identified in 2002 sampling, although some unidentified suckers were collected in 2002. No Lost River suckers were identified in either year.

Table 3-44. Fishery sampling conducted in the J.C. Boyle peaking reach using backpack and boat electrofishing techniques. (Source: PacifiCorp, 2004e, as modified by staff)

		Catch Per Unit Effort (fish per hour)			
	2001[a]	Oregon Reach-2002		Calif. Reach-2002	
Species	(entire reach)	Backpack[b]	Boat[a]	Backpack[c]	Boat[a]
Rainbow trout	112	1.0	25.3	71.9	27.9
Blue chub	--	5.9	--	--	--
Tui chub	16	6.9	--	--	--
Speckled dace	--	193.8	22.1	555.4	2.8
Marbled sculpin	--	126.6	3.16	46.0	--
Sculpin spp.	16	--	--	--	--
Lamprey	--	--	3.16	--	--
Shortnose sucker	8	--	--	--	--
Sucker spp.	--	40.5	9.5	--	60.0
Unknown[d]	--	--	12.6	--	1.4

[a] Sampling was conducted in the fall only.
[b] Average of spring, summer and fall sampling.
[c] Average of summer and fall sampling.
[d] Most likely fathead minnows and/or chubs.

Key tributaries to the peaking reach are Rock Creek at RM 213.9 and Shovel Creek at RM 206.5. Cal Fish & Game considers the lower 2.77 miles of Shovel Creek an important spawning tributary for rainbow trout in the J.C. Boyle peaking reach. Based on extensive electrofishing during 1985 through 1990, Cal Fish & Game (2000) estimated that at least 250 to 300 pairs of adult rainbow trout spawn in Shovel Creek each year. Cal Fish & Game (2000) also concluded that spawning habitat limits production in Shovel Creek. A 1982 survey estimated that a total of 880 square feet of spawning gravel was available, of which only 406 square feet had water depths and velocities preferred by rainbow trout. Up to 15 cfs is currently diverted from Shovel Creek and Negro Creek (a tributary of Shovel Creek) for irrigation purposes during the summer, when fry would be present in both streams.

Copco Reservoir

Copco reservoir was formed when the Copco No. 1 dam was constructed in 1918. The dam is 126-feet high, and does not include any fish passage facilities. The reservoir is 4.5-miles long, has a surface area of 1,000 acres, an average depth of 34 feet, a maximum depth of 108 feet, and a total storage capacity of 33,724 acre-feet. Water levels in Copco reservoir are normally maintained within 6.5 feet of full pool, and daily fluctuations due to peaking operation of the J.C. Boyle and Copco No. 1 developments are typically about 0.5 feet.

The reservoir is located in a canyon area, and is quite large and deep compared to the Keno and J.C. Boyle reservoirs. It contains several coves with more gradual slopes, and large areas of thick aquatic vegetation are common in shallow areas. Nearshore riparian habitat is generally lacking, due to the cliff-like nature of shorelines, and only very small isolated pockets of wetland vegetation exist. As discussed in section 3.3.2.1.2, *Water Quality*, water quality in the reservoir is generally degraded during the summer months, and a predictable sequence of algae blooms occur as temperatures warm, including large blooms of the nitrogen-fixing blue-green algae *Aphanizomenon flos-aquae.*

Fish collections by Oregon State University in Copco reservoir during 1998 and 1999 surveys were dominated by yellow perch, unidentified larval suckers, and golden shiners, which collectively comprised 95 percent of the catch (table 3-45). Approximately 13 percent of the adult fish that were collected in Copco reservoir were federally listed sucker species, nearly all of which were shortnose suckers. Few juvenile suckers were collected in the reservoir, which may reflect predation by non-native species such as yellow perch, largemouth bass, and crappie (Desjardins and Markle, 2000). The investigators speculated that adult suckers that occur in all three project reservoirs may have been produced in Upper Klamath Lake. The chairman of a local landowner association (Copco Lake Community Advisory Committee) reports that fishing derbies and tournaments are held regularly on Copco Lake. Records from several recent derbies (2003) indicate a reasonably healthy fishery, with winning entries for perch ranging from 11 to 12 inches, crappie from 8 to 11 inches, bass from 16 to 19 inches, and trout from 17 to 24 inches in length (letter from B. Davis, Chairman of the Copco Lake Community Advisory Committee, to M.R. Salas, Secretary, FERC, dated July 18, 2004.)

Copco No. 2 Reservoir and Bypassed Reach

The Copco No. 1 powerhouse discharges up to 3,560 cfs directly into Copco No. 2 reservoir, which is approximately 0.25 mile in length, and was formed by the construction of the 33-foot high Copco No. 2 dam in 1925. There are no fish passage facilities at Copco No. 2 development, and due to its small size, PacifiCorp did not conduct any fishery sampling in Copco No. 2 reservoir.

Copco No. 2 dam diverts up to 3,250 cfs into a flow line, leading to a powerhouse at the head of Iron Gate reservoir. Due to the small size of its reservoir, Copco No. 2 development operates in tandem with Copco No. 1 development. Although the existing license does not specify a ramping rate or minimum flow for the bypassed reach, PacifiCorp currently releases 5 to 10 cfs from the dam into the Copco No. 2 bypassed reach, which is 1.5 miles in length. The bypassed reach is in a deep, narrow canyon with a steep gradient similar to that of the upstream Klamath River reaches. The channel consists of bedrock, boulders, large rocks, and occasional pool habitat.

Fisheries sampling conducted by PacifiCorp in 2001 and 2002 indicate that the fish population in the Copco No. 2 bypassed reach is comprised primarily of marbled sculpin and speckled dace, with much smaller numbers of tui chub, rainbow trout, yellow perch, black crappie, largemouth bass, and blue chubs (table 3-46). No suckers of any kind were collected during sampling conducted in this reach.

Table 3-45. Number of fish collected by gear type during 1998 and 1999 in Copco reservoir.[a] (Source: PacifiCorp, 2004e)

	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
Species	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**
Lamprey spp.	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Tui chub	136	101	2	8	0	0	0	0	0	0	0	0	138	109
Blue chub	52	17	0	1	0	0	0	0	0	0	0	0	52	18
Chub spp.	0	0	0	0	0	4	140	53	89	146	0	5	229	208
Golden shiner	0	0	3	1	593	129	0	397	0	5,616	0	0	596	6,143
Fathead minnow	0	0	0	1	0	1	0	0	0	1	0	0	0	3
Klamath speckled dace	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Klamath smallscale sucker	16	1	0	0	0	0	0	0	0	0	0	0	16	1
Klamath largescale sucker	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Shortnose sucker	94	64	0	0	0	0	0	0	0	0	0	0	94	64
Lost River sucker	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Sucker spp.[b]	3	0	0	0	0	54	41	2,979	18	5,160	151	326	213	8,519
Bullhead spp.	182	221	15	178	5	0	0	0	0	0	0	0	202	399
Rainbow trout	3	0	0	0	0	0	0	0	0	0	0	1	3	1
Sculpin spp.	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Sacramento perch	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Pumpkinseed	8	3	30	31	0	5	0	8	0	1	0	0	38	48
Largemouth bass	12	6	2	0	128	8	18	1	0	2	0	0	160	17
Sunfish spp.	0	0	0	0	17	0	9	3	0	1	0	0	26	4
Crappie spp.	57	44	41	30	0	0	7	5	2	18	0	0	107	97
Yellow perch	480	75	92	1,504	16	16,301	5,000	3,274	400	183	2	0	5,990	21,337
Unidentified	0	0	0	0	0	1	12	71	0	73	5	14	17	159
Total Individuals	1,049	532	185	1,755	759	16,516	5,227	6,791	509	11,201	158	346	7,887	37,141
Total Taxa	14	9	7	9	5	10	7	9	4	10	3	4	18	19
Sampling Effort														
Sets/Pulls	17	8	2	14	21	21	18	32	5	14	8	16		
Hours	204	123	35	219	—	—	—	—	—	—	30	73		

[a] Targeted life stage in parentheses after gear type (A = adult, J = juvenile, L = larvae).

[b] Data presented in Desjardins and Markle (2000) indicate that only 3 of the unidentified sucker spp. collected in Copco reservoir in 1998 were juveniles. The rest of the unidentified sucker spp. collected in 1998 and all of the unidentified sucker spp. collected in 1999 in Copco reservoir were larvae.

Table 3-46. Fishery sampling conducted in the Copco No. 2 bypassed reach using backpack electrofishing techniques. (Source: PacifiCorp, 2004e, as modified by staff)

Species	Catch Per Unit Effort (fish per hour)			
	Fall 2001	Spring 2002	Summer 2002	Fall 2002
Rainbow trout	--	--	8.9	21.1
Blue chub	--	--	3.0	--
Tui chub	95.4	--	--	--
Speckled dace	254.3	447.4	608.9	473.0
Marbled sculpin	278.1	109.2	404.9	165.7
Largemouth bass	--	--	--	6.0
Black crappie	--	--	--	15.1
Yellow perch	--	20.8	5.9	--

Spring, Fall, and Jenny Creeks

Jenny and Fall creeks are the only perennial tributaries that enter Iron Gate reservoir (see figure 2-5). Spring Creek is a tributary to Jenny Creek, which flows for a distance of 1.2 miles from its source at Shoat Springs before it enters Jenny Creek at RM 5.5. The total flow delivered from Fall Creek to Iron Gate reservoir typically ranges between 30 and 100 cfs, and flows from Jenny Creek to Iron Gate reservoir typically range between 30 and 500 cfs. The flow in Jenny Creek is altered by upstream reservoirs that store water during the high runoff season for irrigation, and about 30 percent of the mean annual runoff in the basin is diverted into the Rogue River Basin to the north.

PacifiCorp operates a small dam on Spring Creek that diverts flow into Fall Creek, and another dam on Fall Creek diverts flow into a canal that leads to the Fall Creek powerhouse (see figure 2-6). The Spring Creek diversion is located 0.5 mile upstream from its confluence with Jenny Creek, and the diverted flow is carried through a 1.7-mile-long canal where it enters Fall Creek about 1.7 miles upstream of the Fall Creek diversion. The diversion on Fall Creek diverts flow into a canal that bypasses 1.2 miles of Fall Creek, leading to the Fall Creek powerhouse about 0.8 mile upstream from where Fall Creek enters Iron Gate reservoir. The Spring Creek diversion diverts up to 16.5 cfs of flow into Fall Creek, and the Fall Creek diversion diverts up to 50 cfs into the power canal that leads to the powerhouse. The project's current license requires a minimum flow of 0.5 cfs below the Fall Creek diversion and a minimum flow of 15 cfs (or natural stream flow, whichever is less) downstream of the powerhouse.

The Jenny Creek watershed supports several native fish species including the Jenny Creek sucker, rainbow trout, and Klamath speckled dace. PacifiCorp's 2005 sampling collected 5 rainbow trout and 3 suckers in Jenny Creek upstream of the Spring Creek confluence, and 24 rainbow trout and 3 suckers downstream of the confluence (PacifiCorp, 2005a). Sampling in Spring Creek collected 16 rainbow trout upstream of the diversion dam, 1 rainbow trout downstream of the diversion dam, and 6 trout in the diversion canal. Sampling in Fall Creek collected 9 rainbow trout upstream of the diversion, 15 rainbow trout in the bypassed reach, and 1 rainbow trout in the power canal (PacifiCorp, 2005a). Only two of the trout collected were more than 8 inches long. One was collected in Spring Creek upstream of the diversion and the other was collected in Jenny Creek upstream of its confluence with Spring Creek. Spawner surveys conducted by Coots and Wales (1952) indicated that most Chinook salmon spawning habitat and spawning activity in Jenny Creek was located in the lower 3/8 mile of the stream. However, that section of the stream was later inundated by Iron Gate reservoir.

PacifiCorp concludes that the upstream migration of suckers from Jenny Creek is probably precluded by high stream gradient in the lower portion of Spring Creek (PacifiCorp, 2005b). A falls located less than 0.2 miles upstream of the confluence of the Fall Creek powerhouse tailrace is another likely barrier to fish passage. Downstream of the tailrace confluence, Fall Creek is fairly low in gradient, is well shaded with trees, and enters a wetland area at its confluence with Iron Gate reservoir.

Iron Gate Reservoir

Iron Gate reservoir was formed when Iron Gate dam was constructed at RM 190.1 in 1962. The dam is 173 feet high and does not include any fish passage facilities. The reservoir is 6.8 miles long, has a surface area of 944 acres, an average depth of 62 feet, a maximum depth of 167 feet, and a total storage capacity of 50,941 acre-feet. Water levels in Iron Gate reservoir are normally maintained within 4 feet of full pool, and daily fluctuations due to peaking operation of the upstream J.C. Boyle and Copco developments are typically about 0.5 foot.

The reservoir is similar to Copco reservoir in that it is located in a canyon area, and is large and deep with generally steep shorelines except for a few coves with more gradual slopes. Large areas of thick aquatic vegetation are common in shallow areas. Nearshore riparian habitat is generally lacking, except at the mouths of Jenny and Camp creeks, where well developed riparian habitat occurs. Due to the cliff-like nature of shorelines, only very small isolated pockets of wetland vegetation exist around the perimeter of the reservoir. Water quality in the reservoir during the summer is generally quite poor, large blooms of the *Aphanizomenon flos-aquae* occur annually, and surface water temperatures are warm.

Fish collected in Iron Gate reservoir during Oregon State University's 1998 and 1999 surveys were dominated by golden shiners, tui chub, pumpkinseed, unidentified chubs, yellow perch, unidentified larval suckers, and largemouth bass, which collectively comprised 95.1 percent of all fish collected (table 3-47). The federally listed shortnose sucker made up only 1 percent of the total catch of adult fish, and no Lost River suckers were collected in Iron Gate reservoir. Although 1,180 sucker larvae were collected in the reservoir, no juvenile suckers were collected, which may reflect predation by non-native species such as yellow perch, largemouth bass, and crappie (Desjardins and Markle, 2000). Predation rates are probably also high in Copco reservoir, where only 3 juvenile suckers were collected.

Klamath River Downstream of Iron Gate Dam

The Iron Gate development reregulates flow fluctuations caused by peaking operation of the upstream J.C. Boyle and Copco Nos. 1 and 2 developments to provide stable flows downstream of Iron Gate dam. The powerhouse is located at the dam and has a maximum hydraulic capacity of 1,735 cfs. The current license stipulates a minimum flow release at the dam of 1,300 cfs from September through April; 1,000 cfs in May and August; and 710 cfs in June and July. However, since 1997, PacifiCorp has operated the project to provide flow releases dictated by Reclamation's annual operations plans. As discussed previously in section 3.3.2, *Water Resources*, Reclamation develops these annual plans in consultation with FWS and NMFS to comply with recent BiOps for protecting the federally listed coho salmon (NMFS, 2002) and Lost River and shortnose suckers (FWS, 2002a). Ramping rates downstream of Iron Gate dam are limited to 50 cfs per 2 hours not to exceed 150 cfs in 24 hours when flows are 1,750 cfs or less, and 135 cfs per hour not to exceed 300 cfs in 24 hours when flows exceed 1,750 cfs.

Downstream of Iron Gate dam, the Klamath River flows unobstructed for 190 miles before entering the Pacific Ocean. Four major tributaries enter this reach: the Shasta (RM 176.6), Scott (RM 143), Salmon (RM 66), and Trinity (RM 40) rivers. Each tributary supports runs of anadromous salmon and steelhead, although most stocks have declined substantially from historic levels. They also have a substantial influence on the flow volume and water temperatures in the lower portions of the Klamath River. Together, these tributaries contribute 44 percent of the basin's mean annual runoff. The long-term average annual flow of the Shasta, Scott, Salmon, and Trinity rivers is 199, 803, 1,853, and 4,969[65] cfs, respectively. This compares to a mean annual flow of 2,098 cfs at Iron Gate dam and 17,667 cfs at the mouth of the Klamath River. We describe habitat conditions in these tributaries and their use by

[65]Flows from the Trinity River have recently increased under the Trinity River ROD, which reduced the amount diverted from the Trinity River Basin by the State Water Project. The ROD was implemented, in part, in 2001 and went into full effect in November 2004.

Table 3-47. Number of fish collected by gear type during 1998 and 1999 in the Iron Gate reservoir.[a] (Source: PacifiCorp, 2004e)

Species	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Lamprey spp.	0	0	0	4	0	0	0	0	0	0	1	0	1	4
Tui chub	102	40	0	0	0	0	59	0	2,967	7	0	0	3,128	47
Blue chub	50	48	0	0	0	0	0	0	0	0	8	0	58	48
Chub spp.	0	0	0	0	9	0	1,298	9	0	0	7	6	1,314	15
Golden shiner	0	0	0	8	73	32	60	221	0	13,566	0	2	133	13,829
Fathead minnow	0	0	0	0	0	1	0	0	0	2	0	0	0	3
Klamath speckled dace	0	0	0	9	0	0	0	0	0	5	0	0	0	14
Klamath smallscale sucker	11	10	1	0	0	0	0	0	0	0	0	0	12	10
Shortnose sucker	2	11	0	0	0	0	0	0	0	0	0	0	2	11
Sucker spp.[b]	0	1	0	0	0	0	3	114	14	604	25	419	42	1,138
Bullhead spp.	87	83	25	273	1	0	0	0	0	0	0	0	113	356
Channel Catfish	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Rainbow trout	6	2	0	1	0	2	2	4	0	16	0	0	8	25
Sculpin spp.	0	0	0	0	0	0	0	0	0	0	52	24	52	24
Pumpkinseed	18	8	1	41	22	90	6	5	0	2,179	0	2	47	2,325
Green Sunfish	0	0	0	2	2	1	0	0	0	0	0	0	2	3
Largemouth bass	7	5	1	1	277	62	51	9	0	342	0	0	336	419
Sunfish spp.	0	0	0	0	33	0	11	0	0	1	0	0	44	1
Crappie spp.	22	41	12	24	48	0	72	3	14	0	0	3	168	71
Yellow perch	52	247	38	180	9	18	1	17	0	1	33	645	133	1,108
Unidentified	0	0	0	0	0	0	0	4	0	17	7	217	7	238
Total Individuals	357	497	78	543	474	206	1,563	386	2,995	16,740	133	1,318	5,600	19,690
Total Taxa	10	12	6	10	9	7	10	9	3	11	7	8	18	21
Sampling Effort														
Sets/Pulls	19	10	3	12	13	13	17	27	6	25	12	20		
Hours	227	118	56	206	—	—	—	—	—	—	44	87		

[a] Targeted life stage in parentheses after gear type (A = adult, J = juvenile, L = larvae).

[b] Data presented in Desjardins and Markle (2000) indicate that all of the unidentified sucker spp. collected in Iron Gate reservoir in 1998 and 1999 were larvae.

anadromous fish later in this section. Section 3.3.2, *Water Resources*, provides additional information on the hydrology and water quality in these tributaries.

The river basin downstream of Iron Gate dam supports a variety of species of anadromous fish including fall and spring Chinook salmon, coho salmon, steelhead, green sturgeon, and Pacific lamprey. Klamath fall Chinook salmon contribute to important commercial, recreational, and tribal fisheries; steelhead support a popular recreational fishery; and green sturgeon support a small tribal fishery. Coho salmon that occur in the basin are part of the Southern Oregon Northern Coastal California evolutionarily significant unit (ESU), which is federally listed as threatened. Information on the abundance and distribution of anadromous fish, and the condition of aquatic habitat in the Klamath River and its tributaries, is summarized below. Section 3.3.3.1.2, *Anadromous Fish Specie*s, provides information on the biology and population status of these and other anadromous species that occur in the basin downstream of Iron Gate dam. Section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*, provides information on commercial, recreational, and tribal fisheries and harvest management.

The Klamath River downstream of Iron Gate dam supports the spawning and rearing life stages of fall Chinook salmon, and it serves as the migratory corridor for fall Chinook salmon and other anadromous fish that are produced in its tributaries. Between 1978 and 2002, the basin-wide escapement of adult fall Chinook salmon has ranged from a low of 19,121 fish in 1991 to a high of 208,380 fish in 1995 (table 3-48). The number of fall Chinook salmon that spawn in the mainstem Klamath River is a relatively small proportion of the total basin-wide escapement, with estimates between 1978 and 2002 ranging from 580 fish in 1991 to 10,848 fish in 2002. Spawner surveys conducted by FWS indicate that approximately half of the fall Chinook salmon that spawn within the 82-mile survey reach construct their redds in the 13.5-mile section between Iron Gate dam and the Shasta River (table 3-49). We provide additional information on trends in the total escapement of fall Chinook salmon in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*.

Coho salmon and steelhead spawn primarily in the tributaries, but they use the mainstem Klamath as a migration corridor, and may rear for a period in the mainstem river or in the estuary on their way to the ocean. The ability of the mainstem Klamath River to support the rearing and migration of anadromous salmonids is constrained by high water temperatures, poor water quality, and disease outbreaks, especially during the summer months. Temperature refugia provided by inflows from springs and from cooler tributaries are used extensively by rearing and migrating salmonids.

In recent years, substantial losses of juvenile salmonids have occurred during their migration through the lower Klamath River, and a major kill of adult salmon and steelhead occurred in September 2002. These losses have been primarily from disease, and losses observed during juvenile migration monitoring have been especially severe during periods of sustained high water temperatures (Scheiff et al., 2001). Section 3.3.3.1.2, *Anadromous Fish Species*, provides additional information on the thermal tolerance of Klamath River anadromous salmonids, and section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, provides information on losses associated with fish diseases and their relationship to water quality conditions.

Although information on the abundance of non-salmonid species downstream of Iron Gate dam is limited, some information is available from sampling conducted to monitor the outmigration of juvenile salmon and steelhead in the lower Klamath River. Klamath smallscale sucker, Pacific lamprey, and speckled dace were the most common of the non-target species that were collected during screw-trap sampling conducted between 1997 and 2000 in the Klamath River upstream of its confluence with the Trinity River (table 3-50). Sculpins, threespine stickleback, and green sturgeon were the next most abundant species collected.

Table 3-48. Annual escapement of fall Chinook salmon by sub-basin and hatchery, 1978 through 2002. (Source: Cal Fish & Game, 2003, as modified by staff)

Year	Iron Gate Hatchery	Trinity River Hatchery	**Total Hatchery Spawners**	Trinity River Basin	Salmon River Basin	Scott River Basin	Shasta River Basin	Bogus Creek Basin	Mainstem Klamath River	Misc. Klamath and Trinity tributaries	**Total Natural Spawners**	**Total Spawner Escapement**
1978	7,840	7,359	**15,199**	35,764	4,000	5,332	18,731	5,579	2,000	3,500	**74,906**	**90,105**
1979	2,558	2,299	**4,857**	11,964	1,150	3,824	8,151	5,938	4,656	1,715	**37,398**	**42,255**
1980	2,863	6,355	**9,218**	24,537	1,000	4,277	8,096	5,070	3,335	2,150	**48,465**	**57,683**
1981	2,595	3,374	**5,969**	21,246	1,200	6,556	12,220	3,642	4,000	1,500	**50,364**	**56,333**
1982	10,186	6,293	**16,479**	17,423	1,300	10,176	8,455	7,143	4,000	2,100	**50,597**	**67,076**
1983	8,885	5,765	**14,650**	18,137	1,275	3,568	3,872	3,048	2,000	1,410	**33,310**	**47,960**
1984	6,094	2,932	**9,026**	9,070	1,442	1,801	2,842	3,504	1,550	1,140	**21,349**	**30,375**
1985	22,110	20,749	**42,859**	38,671	3,164	4,408	5,124	4,647	624	4,990	**61,628**	**104,487**
1986	18,557	19,404	**37,961**	113,007	3,665	8,041	3,957	7,308	799	5,525	**142,302**	**180,263**
1987	17,014	16,387	**33,401**	77,869	3,950	8,566	4,697	10,956	928	3,523	**110,489**	**143,890**
1988	16,715	22,104	**38,819**	55,242	3,600	5,200	2,842	16,440	3,146	5,460	**91,930**	**130,749**
1989	11,690	11,371	**23,061**	31,988	3,610	4,188	1,577	2,662	1,225	4,127	**49,377**	**72,438**
1990	7,025	1,719	**8,744**	7,923	4,667	1,615	533	785	564	859	**16,946**	**25,690**
1991	4,067	2,687	**6,754**	5,249	1,480	2,165	726	1,281	580	886	**12,367**	**19,121**
1992	7,318	3,990	**11,308**	9,702	1,325	2,838	586	1,154	600	966	**17,171**	**28,479**
1993	21,711	1,551	**23,262**	8,370	3,533	5,300	1,426	3,716	678	2,660	**25,683**	**48,945**
1994	12,233	7,706	**19,939**	13,411	3,493	2,863	5,203	8,260	3,874	1,474	**38,578**	**58,517**
1995	14,008	15,254	**29,262**	87,138	5,475	14,477	13,511	46,432	7,240	4,845	**179,118**	**208,380**
1996	14,165	6,660	**20,825**	47,124	5,463	12,097	1,450	10,797	3,008	7,561	**87,500**	**108,325**
1997	13,727	6,207	**19,934**	14,352	6,000	8,561	2,001	10,030	3,576	5,849	**50,369**	**70,303**
1998	15,326	14,488	**29,814**	26,434	1,453	3,327	2,542	6,835	3,022	1,730	**45,343**	**75,157**
1999	14,120	7,064	**21,184**	10,907	780	3,584	3,197	6,165	2,608	1,663	**28,904**	**50,088**
2000	72,474	27,046	**99,520**	26,844	1,772	6,253	12,296	35,051	3,455	3,451	**89,122**	**188,642**
2001	38,568	18,175	**56,743**	37,327	3,350	6,142	11,093	12,575	10,848	4,245	**85,580**	**142,323**
2002	24,961	4,549	**29,510**	13,332	2,558	4,308	6,818	17,834	22,308	2,129	**69,287**	**98,797**
Average	15,472	9,660	**25,132**	30,521	2,828	5,579	5,678	9,474	3,625	3,018	**60,723**	**85,855**
% of total	18.0%	11.3%	**29.3%**	35.5%	3.3%	6.5%	6.6%	11.0%	4.2%	3.5%	**70.7%**	**100.0%**

Table 3-49. Distribution of fall Chinook salmon spawning redds observed from 1993 through 2002 from Iron Gate dam to Indian Creek. (Source: Grove, 2002)

Tributary Reach (RM)	Percent of Total									
	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Iron Gate (190.1) to Cape Horn Ck (186.8)	24.2	38.9	39.1	40.9	45	55.1	60.9	37.5	25.8	31.9
Cape Horn Ck (186.8) to Shasta River (176.6)	2.1	11.1	15.6	10.6	14.2	16.1	11.7	12.5	12.4	13.5
Shasta River (176.6) to Humbug Ck (173.8)	2.7	1.1	1.9	0.8	1.1	3.3	3.5	8	3.6	3.4
Humbug Ck (173.8) to Vesa Ck (166.7)	7.9	3.4	4.9	3.3	4.3	3	0.9	5.1	7.2	5.9
Vesa Ck (166.7) to Little Humbug Ck (160.0)	7.9	2.7	4.9	4.2	2.3	4.3	3.3	3.6	6.7	5.4
Little Humbug Ck (160.0) to Kohl Ck (154.1)	2.4	4.2	1.2	2.4	0.9	0.4	1.2	2.1	4.2	4.2
Kohl Ck (154.1) to Kinsman Ck (147.3)	5.5	2.2	1.1	1.1	1.8	1.6	2.9	3.5	2.8	3.8
Kinsman Ck (147.3) to Kuntz Ck (141.2)	6.4	5.6	3.8	1.8	8.6	2.5	1.9	6.8	7.1	6.6
Kuntz Ck (141.2) to Walker Ck (134.8)	7.6	5.2	3.9	5.5	1		2.1	2.5	2.5	2.5
Walker Ck (134.8) to Portuguese Ck (129.0)	6.7	2.2	4.4	6	1.8	0.4	0.3	0.4	1.7	1.5
Portuguese Ck (129.0) to Shinar Ck (123.7)	12.4	7.1	6	10.7	6.5	4.7	3.6	7.5	9.7	5
Shinar Ck (123.7) to China Ck (119.3)	5.8	6.9	5.2	4.8	3.3	3	2.9	7.5	10.3	7.7
China Ck (119.3) to Ottley Gulch (114.2)	1.2	3.9	2.2	3.1	1.4	1.4	1.6	1.3	3.2	3.5
Ottley Gulch (114.2) to Indian Ck (108.0)	7.3	5.4	5.8	4.8	7.6	3.5	3	3.9	2.8	5.2

Table 3-50. Non-target species (excluding Chinook salmon, coho salmon, and steelhead) collected during screw-trap sampling conducted at Big Bar (RM 49.7) on the Klamath River and at Willow Creek (RM 21.1) on the Trinity River, 1997-2000. (Source: Scheiff et al., 2001)

	Total Number Captured										
	Klamath					Trinity					
Common Name	**1997**	**1998**	**1999**	**2000**	**Total**	**1997**	**1998**	**1999**	**2000**	**Total**	**Species Total**
Klamath smallscale sucker	1,930	388	285	132	2,735	6,403	1,923	1,045	514	9,885	12,620
Pacific lamprey	1,085	1,444	2,121	815	5,465	1,281	1,140	387	28	2,836	8,301
Klamath speckled dace	618	147	167	130	1,062	950	385	476	519	2,330	3,392
Sculpin	186	24	42	14	266	123	13	58	31	231	497
Threespine stickleback	6	0	0	0	6	103	16	0	197	371	377
Green sturgeon	127	9	80	10	226	49	16	0	0	65	291
Golden shiner	3	49	196	20	228	3	4	7	8	22	290
Sockeye salmon	0	0	0	0	0	17	30	223	13	283	283
American shad	11	0	2	1	14	148	2	0	73	223	237
Brown bullhead	3	5	2	1	11	6	0	32	1	39	50
Brown trout	2	1	0	0	3	6	0	3	10	19	22
Fathead minnow	2	0	2	9	13	0	0	0	0	0	13
Green sunfish	0	1	2	0	3	5	1	1	0	7	10
Crappie	2	0	1	0	3	0	0	0	0	0	3
Largemouth bass	0	0	0	0	0	0	0	0	0	0	0
Season Total	**2,045**	**1,680**	**2,615**	**1,000**	**7,340**	**2,691**	**1,607**	**1,248**	**880**	**6,426**	**13,766**
Days Trapped	**126**	**96**	**116**	**93**		**231**	**206**	**191**	**143**		

Lower Klamath River Tributaries

The tributaries downstream of Iron Gate dam provide important spawning and rearing habitat for fall and spring Chinook salmon, coho salmon, and steelhead. This section describes historical and current use by anadromous fish and the condition of habitat in the four largest tributaries, the Shasta, Scott, Salmon, and Trinity rivers. Bogus Creek, a smaller tributary that enters the Klamath River 0.5 mile downstream of Iron Gate dam, also provides important spawning habitat for fall Chinook and coho salmon. Available information on the use of Bogus Creek and other smaller tributaries by anadromous fish is provided in section 3.3.3.1.2, *Anadromous Fish Species.*

Shasta River. The Shasta River enters the Klamath River at RM 176.6, 13.5 miles downstream from Iron Gate dam. The Shasta River currently provides approximately 35 miles of fall Chinook salmon habitat, 38 miles of coho salmon habitat, and 55 miles of steelhead habitat (Hardy and Addley, 2001). Dwinnell dam, constructed on the Shasta River at RM 37 in 1926, eliminated access to about 22 percent of the habitat that was historically available to salmon and steelhead in the Shasta River. The formerly large run of spring Chinook salmon in the Shasta River was lost around the time that Dwinnell dam was constructed (NAS, 2004). Current anadromous fish production in the basin is thought to be limited by low flows and high water temperatures, stream diversions, and degraded spawning gravels (Hardy and Addley, 2001). Cumulative water withdrawals in conjunction with groundwater pumping during the agricultural season may restrict access by fall Chinook salmon to the lower 10 to 15 miles of the river. Stream temperatures are adversely affected by reduced flows, agricultural return flows, and loss of riparian vegetation from overgrazing (Hardy and Addley, 2001).

The Shasta River is reported to have been one of the most productive salmon streams in California because of its combination of continuous flows of cold water from springs, low gradients, and naturally productive waters (NAS, 2004). Cal Fish & Game has operated a fish counting facility on the lower Shasta River since 1930, which provides the longest record of abundance trends of anadromous salmonids in the Klamath River Basin. Currently, the facility consists of a video fish counting weir. The facility is operated primarily during the fall Chinook salmon migration, so counts of other species are not comprehensive but they do provide an indication of abundance trends over time. Based on weir counts and spawner surveys conducted in the Shasta River downstream of the fish counting facility, the number of fall Chinook salmon that returned to the Shasta River exceeded 80,000 fish as recently as 1931, but runs of fall Chinook salmon have generally been less than 10,000 fish since the mid 1940s. Fall Chinook salmon runs were generally less than 5,000 fish from 1983 through 1999, but rebounded to between 6,000 and 12,000 fish from 2000 through 2002 (figure 3-57). Counts of coho salmon at the Shasta fish counting facility have typically been less than 400 fish, and annual counts were 30 fish or less from 1985 through 2000 (figure 3-58). Counts of steelhead at the facility frequently exceeded 1,000 fish prior to 1943 and occasionally through the early 1980s, but since 1988 fewer than 20 steelhead have been counted in each year through 1996 (figure 3-59).

Cal Fish & Game monitored the outmigration of juvenile Chinook salmon, coho salmon, and steelhead in the Shasta River using a rotary screw trap from late February through early July 2002 (Chesney and Yokel, 2003). A total of 526,256 Chinook salmon, 8,294 steelhead, and 747 coho salmon juveniles (fry, parr, and smolts) were captured. An estimated 3,135,902 Chinook salmon smolts migrated during a 14-week period with peak emigration in mid-March, and an estimated 6,657 steelhead migrated during a 7-week period with peaks in mid-April for smolts and early June for pre-smolts (parr). Too few coho salmon smolts (300) were captured to estimate total number of coho salmon outmigrants, although there were peak catches in late April and late May. Many steelhead and coho salmon outmigrants were age 0+ fish that moved from the Shasta River to the Klamath River as Shasta River flows declined (Chesney and Yokel, 2003).

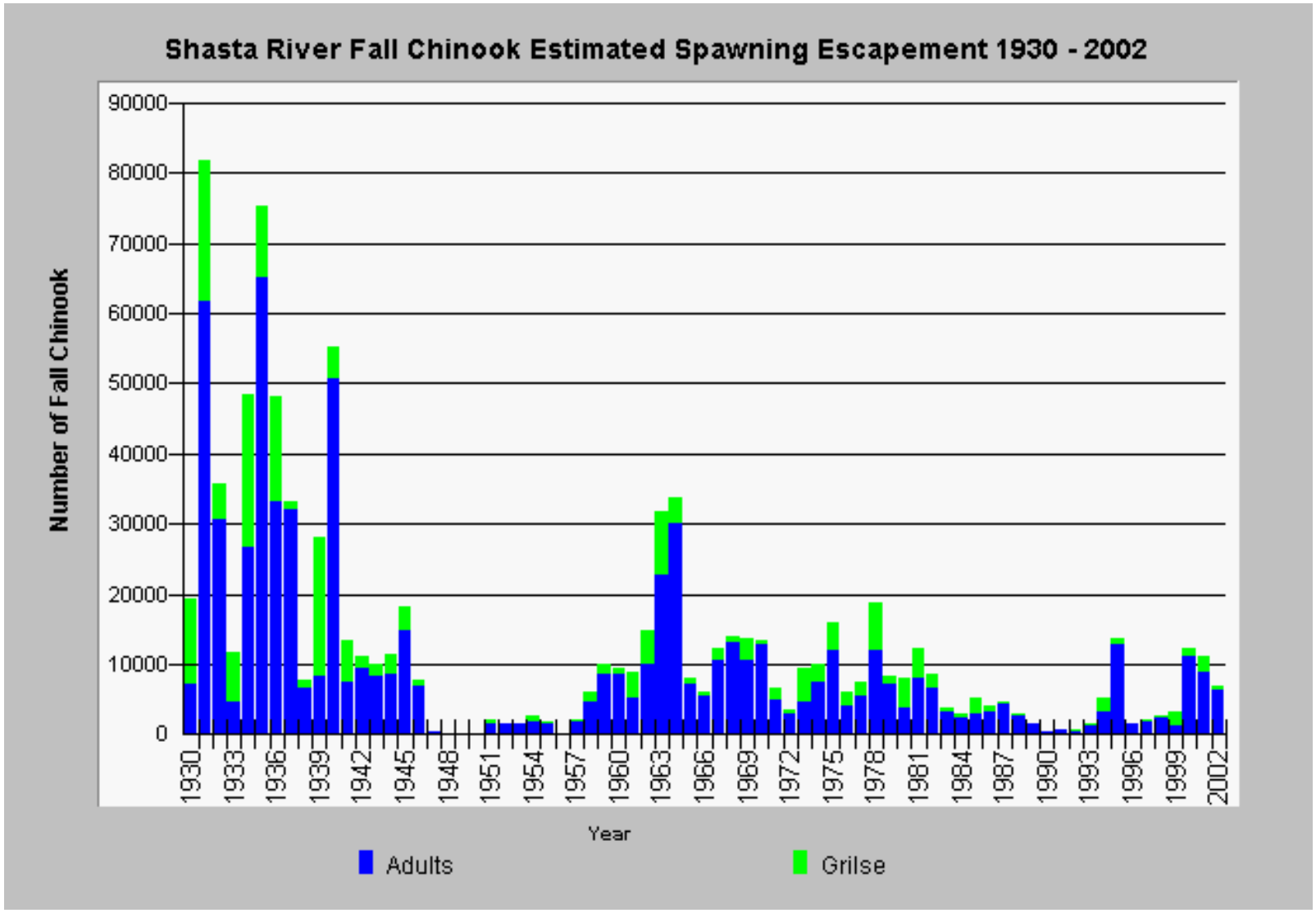

Figure 3-57. Shasta River estimated spawning escapement of grilse and adult fall Chinook salmon, 1930 to 2002. Note: Grilse (jacks) are precocious adult Chinook salmon males that have spent only one year in the ocean. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sh_c11.htm, accessed on August 27, 2006)

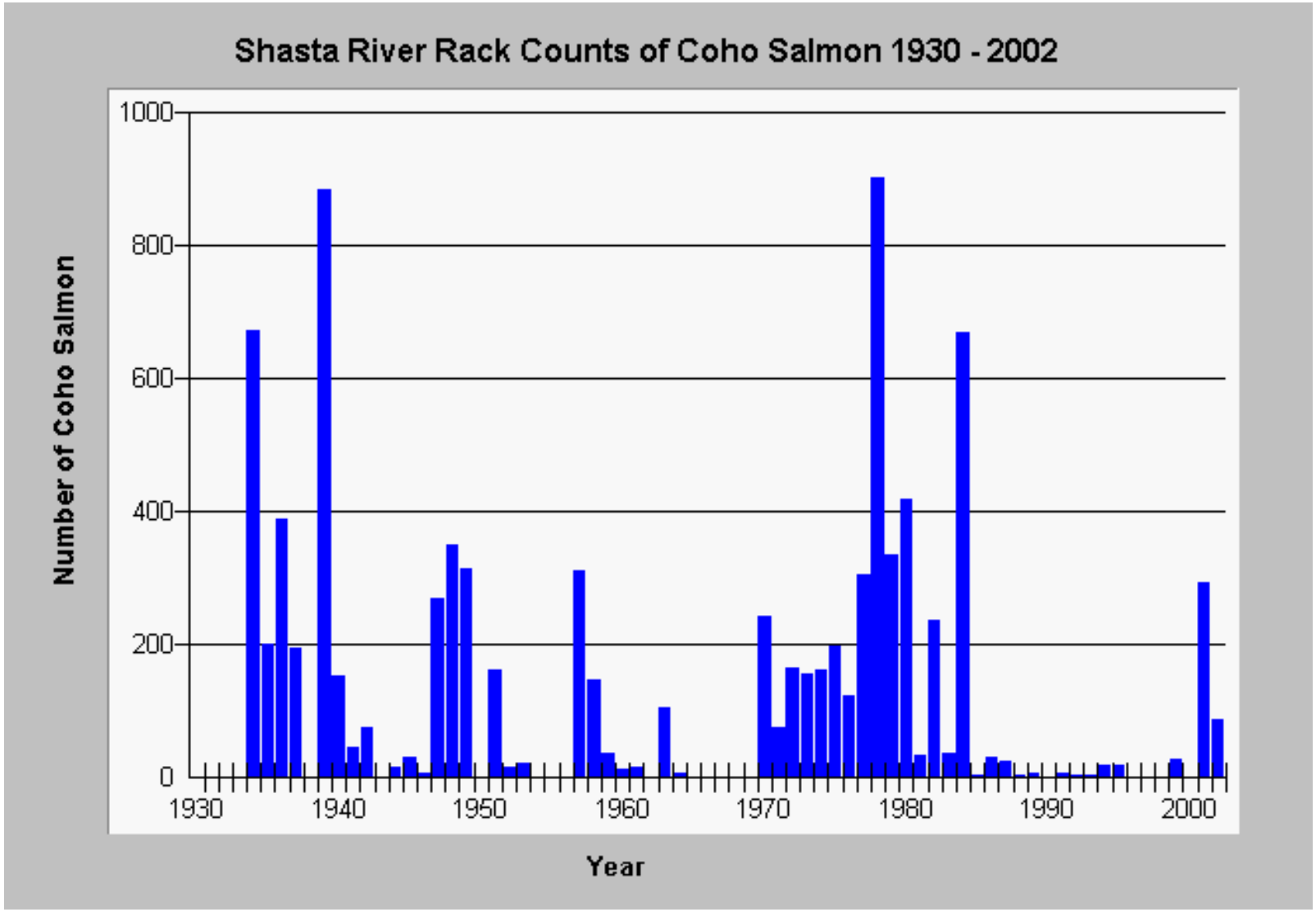

Figure 3-58. Shasta River weir counts of coho salmon, 1930 to 2002. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sh_c15.htm, accessed on August 27, 2006)

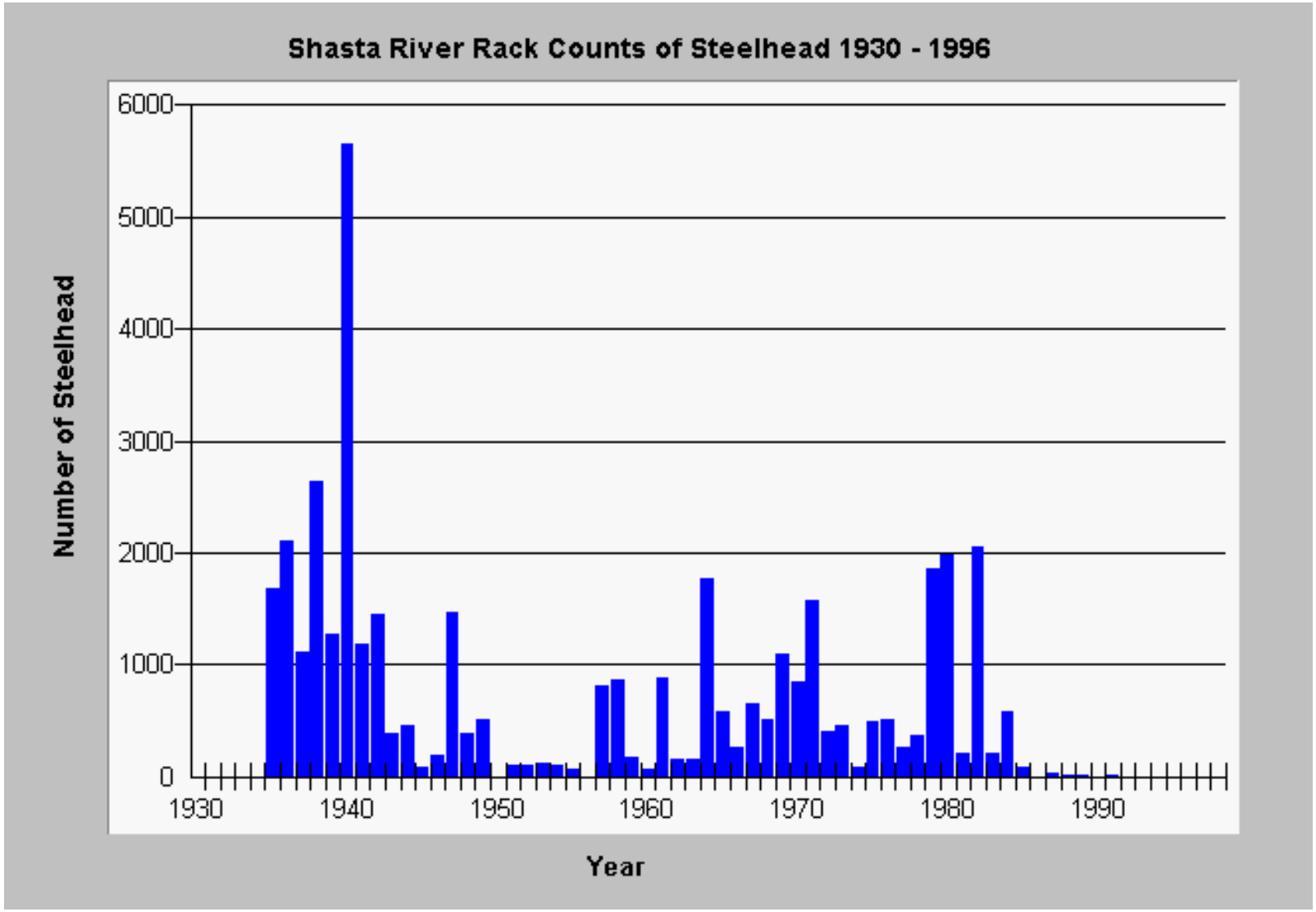

Figure 3-59. Shasta River weir counts of adult steelhead, 1930 to 1996. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sh_c16.htm, accessed on August 27, 2006)

Scott River. The Scott River enters the Klamath River at RM 143, 33.6 miles downstream of the Shasta River. Including tributaries, the Scott River Basin presently has about 59 stream miles of habitat suitable for fall Chinook salmon, 88 miles of habitat suitable for coho salmon, and 142 miles of habitat suitable for steelhead (Hardy and Addley, 2001). Anadromous fish production within the Scott River Basin is affected by reduced flows, degraded spawning habitat, high summer water temperatures, and several unscreened diversions. Cumulative water withdrawals in conjunction with groundwater pumping during the agricultural season currently limit upstream migration of fall Chinook salmon to the lower 42 miles of the mainstem Scott River (Hardy and Addley, 2001). The mainstem channel of the Scott River has been extensively altered by placer and hydraulic mining, logging, grazing, elimination of wetlands, and flood-management or bank-stabilization efforts (NAS, 2004). However, locally driven efforts are under way in the Scott Valley to improve water quality and salmonid spawning and rearing habitat, and fish screens have been installed at many of the water diversions in the basin (NAS, 2004).

Between 1978 and 2002, estimated spawning escapement of fall Chinook salmon to the Scott River ranged from 1,615 in 1990 to 12,657 fish in 1995 (see table 3-48). Although quantitative estimates of steelhead and coho salmon escapement are not available, a survey conducted in several tributaries to the Scott River during the 2001/2002 spawning season identified 212 coho salmon redds, 173 live coho salmon, and 115 carcasses (Maurer, 2002). Cal Fish & Game monitored the outmigration of juvenile Chinook salmon, coho salmon, and steelhead in the Scott River using a rotary screw trap from late February through mid-July 2002 (Chesney and Yokel, 2003). A total of 11,793 Chinook salmon, 11,918 steelhead, and 1,939 coho salmon juvenile (fry, parr, and smolts combined) were captured. An estimated 319,286 Chinook salmon smolts migrated during an 8-week period and 5,088 steelhead smolts migrated during a 5-week period. Peak catches of both species occurred from late March to early April and from late June to early July. Too few coho salmon smolts (6) were captured to estimate total number of coho salmon outmigrants, although there were peak catches in mid- to late June (Chesney and Yokel, 2003).

Salmon River. The Salmon River enters the Klamath River at RM 66, 77 miles downstream of the Scott River. It is one of the most pristine watersheds within the Klamath River Basin, and a high percentage of the watershed is protected under a wilderness designation. Hardy and Addley (2001) estimate that the watershed currently has 81 stream miles of fall Chinook salmon habitat and 85 miles of coho salmon habitat, and the amount of steelhead habitat was considered to be similar to the amount for coho salmon. NAS (2004) states that the watershed supports 140 miles of fall Chinook salmon habitat and 100 miles of coho salmon and steelhead habitat. Hardy and Addley (2001) indicate that there are no substantial impediments to anadromous fish production in the Salmon River Basin, although areas of unstable spawning gravels have been identified, and water temperatures can be higher than optimal for rearing salmonids at some times and locations. NAS (2004) states that logging roads, road crossings, and frequent fires in the basin contribute to high sediment yields, and that historical and continued placer mining has reduced riparian cover and disturbed spawning and holding habitat.

The Salmon River supports spring and fall Chinook salmon, coho salmon, steelhead, Pacific lamprey, and green sturgeon (Hardy and Addley, 2001). The estimated escapement of fall Chinook salmon to the Salmon River Basin between 1978 and 2001 ranged from 780 fish in 1999 to 6,000 fish in 1997 (see table 3-48). Estimated escapement of spring Chinook salmon to the Salmon River Basin between 1980 and 2002 ranged from 143 fish in 1983 to 1,443 fish in 1995 (figure 3-60). Estimated escapement of summer steelhead to the Salmon River Basin typically exceeded 300 fish between 1980 and 1988, decreased to less than 100 fish from 1995 through 2000, and rebounded to over 300 fish in 2001 and 2002 (figure 3-61). Green sturgeon counted during snorkel surveys conducted by the Yurok Tribe in 2002 peaked at 11 fish in late May and 14 fish in early June, but dropped to zero fish on June 11, suggesting that the sturgeon had likely spawned and moved downstream.[66]

[66]Information from http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sa_ct9.htm, accessed August 27, 2006.

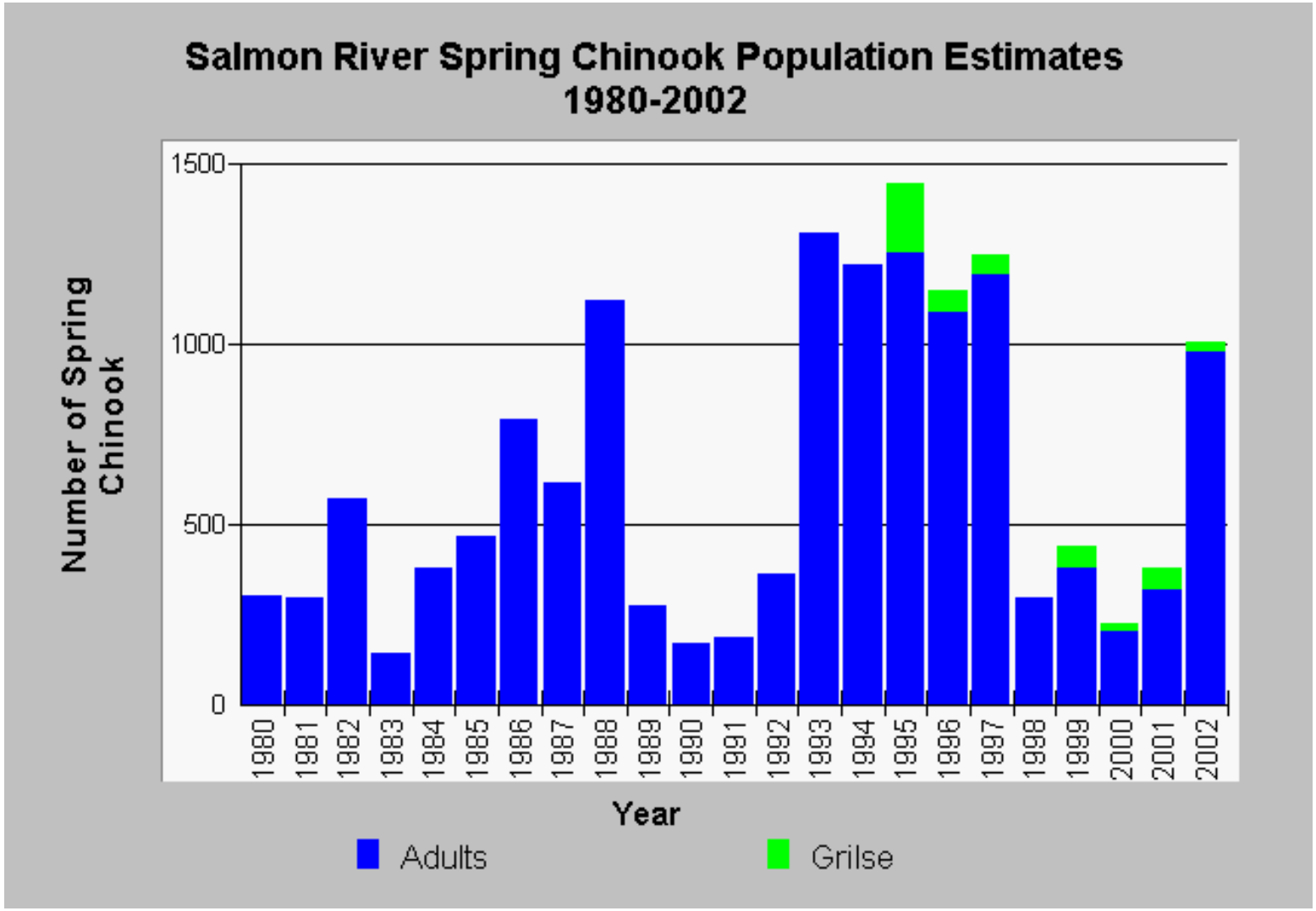

Figure 3-60. Salmon River estimated spawning escapement of grilse and adult spring Chinook salmon, 1980 to 2002. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sa_c8.htm, accessed on August 27, 2006)

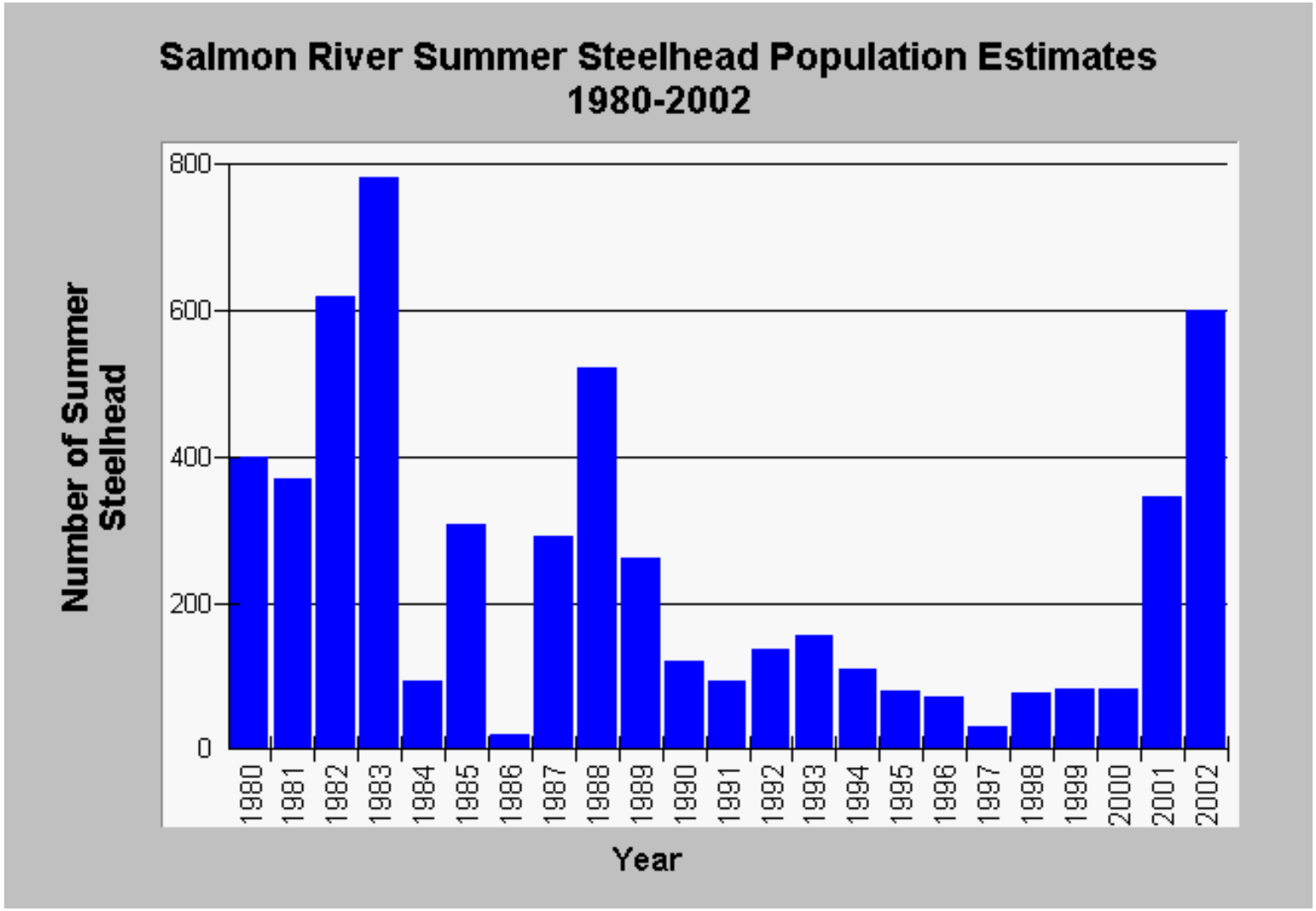

Figure 3-61. Salmon River estimated spawning escapement of steelhead, 1980 to 2002. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sa_c11.htm, accessed on August 27, 2006)

Trinity River. The Trinity River enters the Klamath River at RM 40, 26 miles downstream of the Salmon River. Prior to the construction of TRD of the Reclamation Central Valley Project in the early 1960s, the Trinity River accounted for close to one-third of the average total runoff from the Klamath River Basin. The TRD consists of Trinity dam (at RM 116), which has an impoundment capacity of 2.4 million acre-feet, and Lewiston dam (at RM 109), which diverts water to the Central Valley Project. Construction of the TRD eliminated access for anadromous fish to approximately 59 miles of Chinook salmon spawning habitat and 109 miles of steelhead habitat (Hardy and Addley, 2001).

Following construction of the TRD, the flows below Lewiston dam were reduced by approximately 80 percent, and the contribution of the Trinity River to the total flow of the Klamath River declined from 32 to about 26 percent. As discussed in section 3.3.2, *Water Resources*, flows released into the Trinity River have recently been increased under the Trinity River ROD, which was implemented, in part, in 2001 and went into full effect in November 2004. Because the waters released from Trinity dam remain relatively cool throughout the summer and early fall months, increased flows required under the ROD have the potential to reduce water temperatures in the lower Trinity River and in the Klamath River downstream of its confluence with the Trinity.

Hardy and Addley (2001) state that the mid-Trinity River Basin (Lewiston dam to the confluence with the South Fork Trinity) has about 140 stream miles of habitat suitable for Chinook and coho salmon, and about 225 miles of steelhead habitat. They also estimate that the South Fork Trinity has 115 stream miles of habitat suitable for Chinook and coho salmon, and about 190 miles of steelhead habitat. They did not estimate the amount of salmonid habitat in the lower Trinity River Basin, but they state that the lower basin contains important habitat for spawning fall and spring Chinook salmon, winter and fall steelhead, coho salmon, green sturgeon, and Pacific lamprey.

Hardy and Addley (2001) consider the primary factors that limit anadromous fish production in the Trinity basin to be reduced flows and migration blockages from agricultural diversions, reduced water quality, sedimentation, riparian encroachment, and the effects of large flood events. In the South Fork subbasin, they state that fires, timber harvest, road construction and historic mining practices, and large flood events have played a role in the loss of anadromous fish production.

The estimated escapement of fall Chinook salmon to the Trinity River Basin between 1977 and 2002 ranged from 7,936 fish in 1991 to 132,411 fish in 1986 (see table 3-48). The estimated escapement of spring Chinook salmon to the basin between 1978 and 2002 ranged from 1,315 fish in 1983 to 53,852 fish in 1988 (figure 3-62). The estimated escapement of coho salmon to the basin between 1977 and 2002 ranged from 239 fish in 1994 to 51,826 fish in 1987 (figure 3-63). We have not located any estimates of steelhead escapement for the Trinity basin.

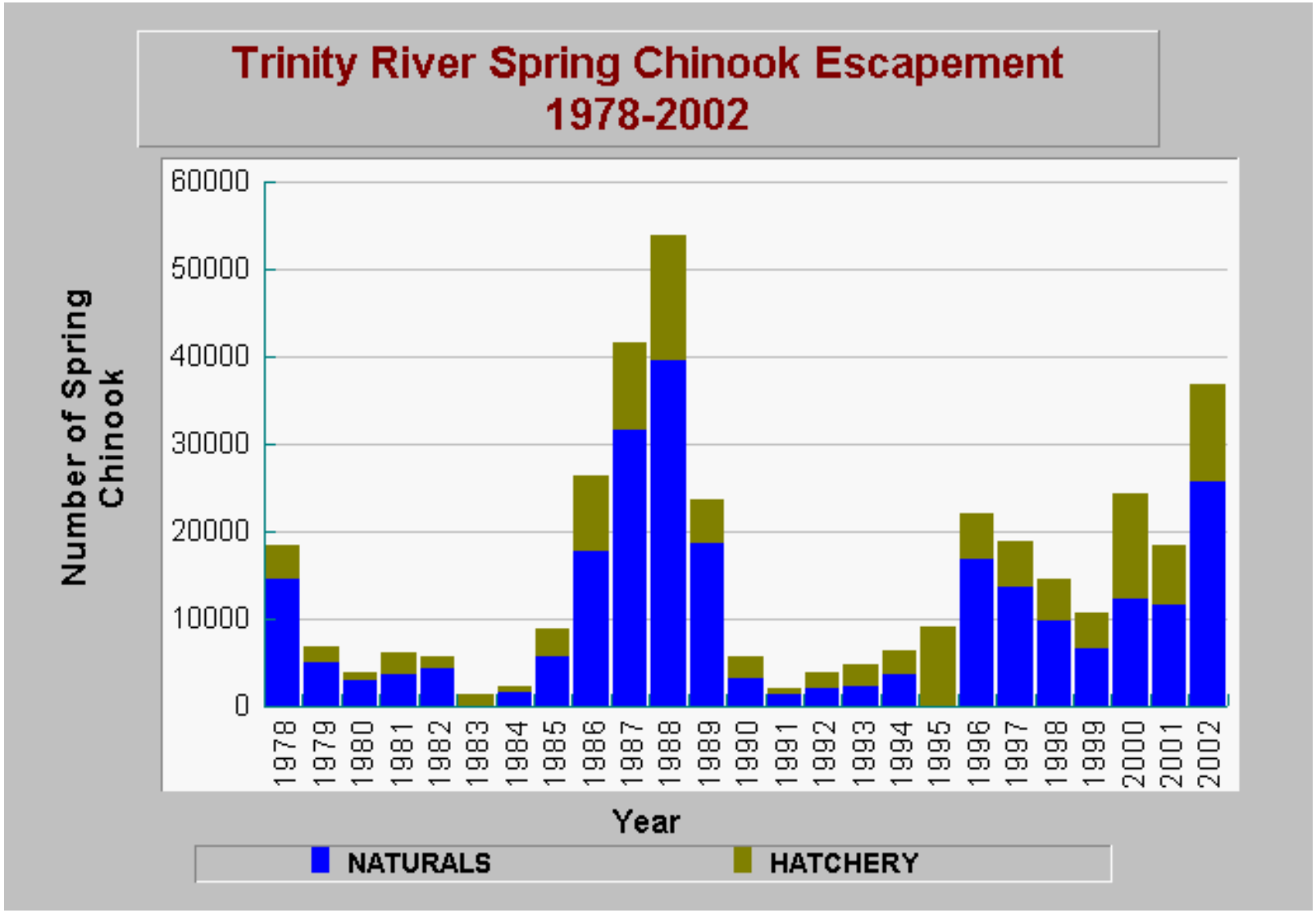

Figure 3-62. Trinity River estimated spawning escapement of naturally spawning and hatchery spawned spring Chinook salmon, 1978 to 2002. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/mt_c10.htm, accessed on August 27, 2006)

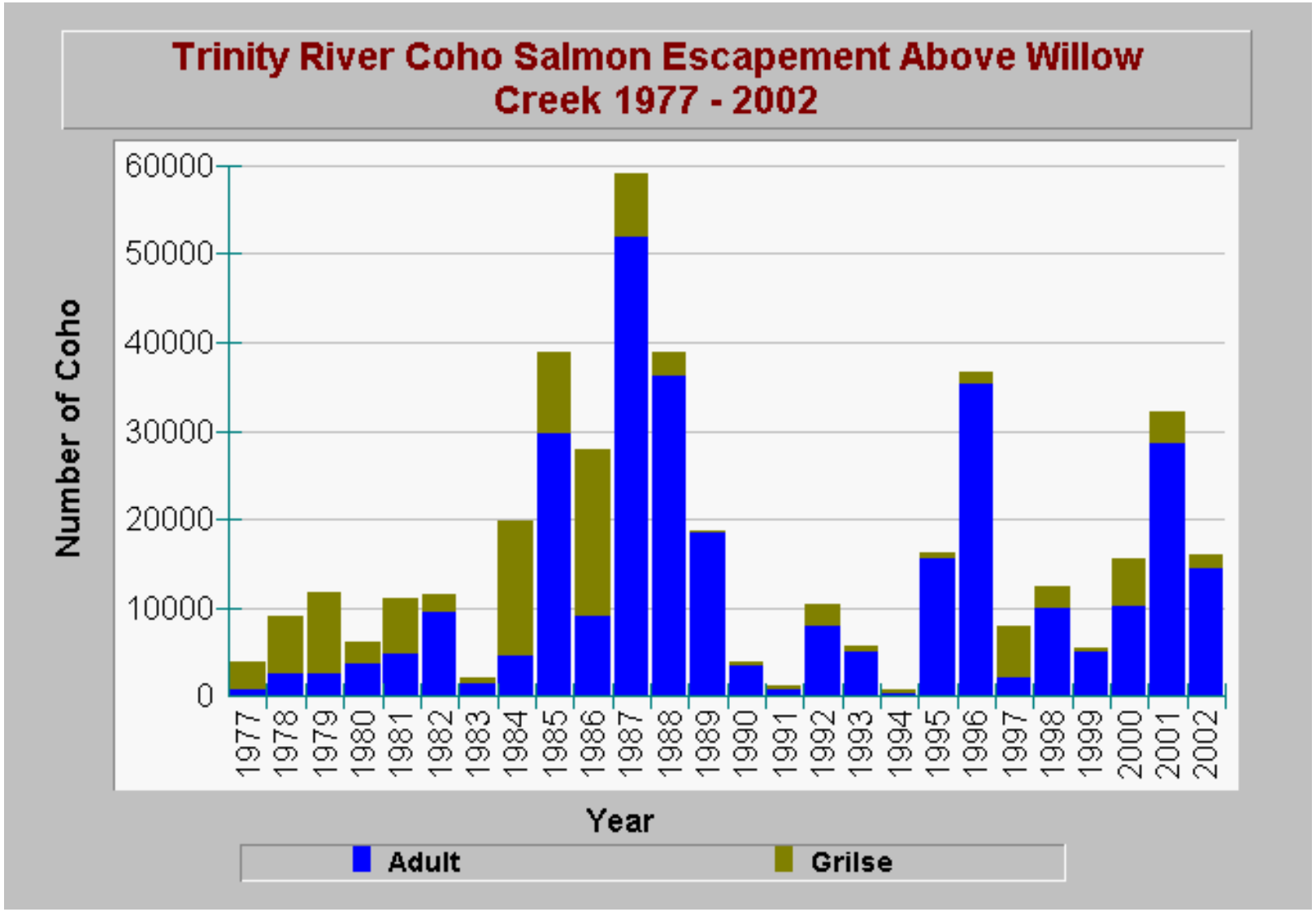

Figure 3-63. Trinity River estimated spawning escapement of grilse and adult coho salmon above Willow Creek, 1977 to 2002. (Source: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/mt_c15.htm, accessed on December August 27, 2006)

3.3.3.1.2 Anadromous Fish Species

Fall Chinook Salmon

Historical records reviewed by Hamilton et al. (2005) indicate that large numbers of Chinook salmon spawned in the tributaries upstream of Upper Klamath Lake, including the Sprague, Williamson, and Wood rivers. Most accounts indicate that the spring run may have been the dominant run in the basin prior to development, but Hamilton et al. (2005) also concluded that the runs to the upper basin must have included a fall-run component based on the size of the salmon harvested (up to 60 pounds) and the timing of spawning noted by Lane and Lane Associates (1981). The latter reference, which was based on 50 interviews with members of the Klamath Tribe conducted in the 1940s, documented tribal salmon fisheries on the Sprague River extending to its upstream limit within the reservation (near the town of Bly), on the Williamson River, and in Upper Klamath Lake. Hamilton et al. (2005) also cited several reports of Chinook salmon spawning in tributaries between Upper Klamath Lake and Iron Gate dam including Spencer, Shovel, Fall, and Jenny creeks.

Huntington (2004) estimated that the Klamath River and its tributaries between Upper Klamath Lake and Iron Gate dam historically provided 68 miles of habitat for Chinook salmon, the Sprague River system provided 307 miles of Chinook salmon habitat, the Williamson River system provided 47 miles of Chinook salmon habitat, and the Wood River and other small tributaries to Upper Klamath Lake provided 148 miles of Chinook salmon habitat. He also estimated pre-development returns of salmon and steelhead to the watershed upstream of Upper Klamath Lake based on production rates documented in the Shasta River Basin, expanded based on watershed area (which he considered to produce a low end estimate) and mean annual flow (which he considered to produce a high end estimate). Using this method, Huntington (2004) estimated that the historic returns of adult Chinook salmon to areas upstream of Upper Klamath Lake were between 149,734 and 438,023 fish per year, and were most likely in the lower end of this range.

The total escapement of fall Chinook salmon from 1978 to 2002 to the Klamath River and its tributaries, and to the two hatcheries in the basin (the Iron Gate and Trinity hatcheries) has averaged 85,855 fish over this time period, and returns to the hatcheries have constituted an average of 29.3 percent of returning fall Chinook salmon (see table 3-48). Natural spawners, including stray fish from hatchery releases, constituted the remaining 70.7 percent of the fall Chinook salmon escapement. Among naturally spawning fish, the greatest proportions have returned to the Trinity basin (35.5 percent of the total escapement) and Bogus Creek (11.0 percent of the total escapement). The mainstem Klamath River only accounted for 4.2 percent of the total escapement.

NMFS considers fall Chinook salmon present downstream of the Trinity River-Klamath River confluence to belong to the Southern Oregon and Northern California Coastal Chinook salmon ESU. Fall and spring Chinook salmon upstream of the Trinity confluence are both considered to be part of the Upper Klamath-Trinity Rivers Chinook salmon ESU. Neither ESU is currently listed under the ESA.

Fall Chinook salmon in the Klamath River spend less than a year in freshwater, a life history strategy that allows them to take advantage of streams in which temperature conditions may become unfavorable by late summer (Moyle, 2002). Snyder (1931) referred to the run as a summer run, because fish started entering the estuary and lower river in early July and the run peaked in August before declining in September. Today, the run peaks in early September and continues through late October (NAS, 2004). The run timing reported by NAS is consistent with angler harvest rates reported in Hopelain (2001), which peaked between the last week in August and the first week in September from 1984 through 1987. NAS (2004) suggests that this shift in run timing may be a response to mainstem water temperatures becoming less favorable to adult salmon in the summer, or perhaps due to excessive harvest of early run fish.

Even with the current run timing, the temperature during the spawning run is probably stressful to the migrating salmon, and may result in increased mortality of spawning adults or reduced egg viability. Literature reviewed by Bartholow (1995) suggests that water temperatures between 6 and 14°C are optimal for adult migration and that chronic exposure of migrating adults to 17 to 20°C water can be lethal, although they can endure temperatures as high as 24°C for short periods. Spring Chinook salmon typically migrate at 3.3 to 13.3°C, summer Chinook salmon migrate at 13.9 to 20.0°C, and fall Chinook salmon migrate at 10.6 to 19.4°C (Bell, 1991). In the lower portions of the Klamath River, water temperatures during the spawning migration typically approach a maximum of 21°C or higher in August and September, and occasionally exceed 26°C in the mid-reaches of the Klamath River (Cal Fish & Game, 2004a). High water temperatures appear to contribute to the incidence of disease outbreaks that may cause substantial mortality of migratory juvenile and adult fall Chinook salmon, including the major kill of adult salmon that occurred in September 2002. Additional information on losses associated with fish diseases and their relation to water quality conditions is provided in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*.

Fall Chinook salmon reach their upstream spawning grounds within 2 to 4 weeks after they enter the river, after which they spawn and die. Spawning normally peaks during mid-October, and is complete by the middle of November (NAS, 2004). Time to emergence is dependent on the temperature regime. In the mainstem Klamath River, alevins can emerge from early February through early April, but peak times vary from year to year. After they emerge, fry disperse downstream, and many then take up residence in shallow water on the stream edges, often in flooded vegetation, where they may remain for various periods. As they grow larger, they move into faster water. Some fry, however, keep moving after emergence and reach the estuary for rearing.

Fall Chinook salmon fry rear in the mainstem at temperatures of 19 to 24°C (NAS, 2004). That pattern is consistent with the thermal tolerances of juvenile Chinook salmon, which can feed and grow at continuous temperatures up to 24°C when food is abundant and other conditions are not stressful (Myrick and Cech, 2001). Under constant laboratory conditions, optimal temperatures for growth are around 13 to 16°C. Continuous exposure to temperatures of 25°C or higher is invariably lethal, although the time until mortality depends on the acclimation temperature of the fish (McCullough, 1999). Juveniles can, however, tolerate higher temperatures (28 to 29°C) for short periods (NAS, 2004). Depending on their thermal history, fish in wild populations may experience high mortality at temperatures as low as 22 to 23°C (McCullough, 1999). In the lower Klamath River, the presence in late summer of refugia that are 1 to 4°C cooler than the mainstem and lower temperatures at night increase the ability of fry to grow and survive. The abundance of invertebrate food also makes the environment bioenergetically favorable, although intense competition for food and space may occur around the refuge pools (NAS, 2004).

Juvenile Chinook salmon are found in the Klamath estuary from March through September, over which time new fish constantly enter and older fish leave (NAS, 2004). Migrant sampling conducted from 1997 through 2000 at Big Bar on the Klamath River (RM 49.7) and at Willow Creek on the Trinity River (RM 21.1) indicates that the peak outmigration of fall Chinook salmon smolts occurs in June and July in the Klamath River (figure 3-64) and from June through August in the Trinity River (figure 3-65). In both rivers, the outmigration timing is similar for wild and hatchery subyearling (age 0+) smolts.

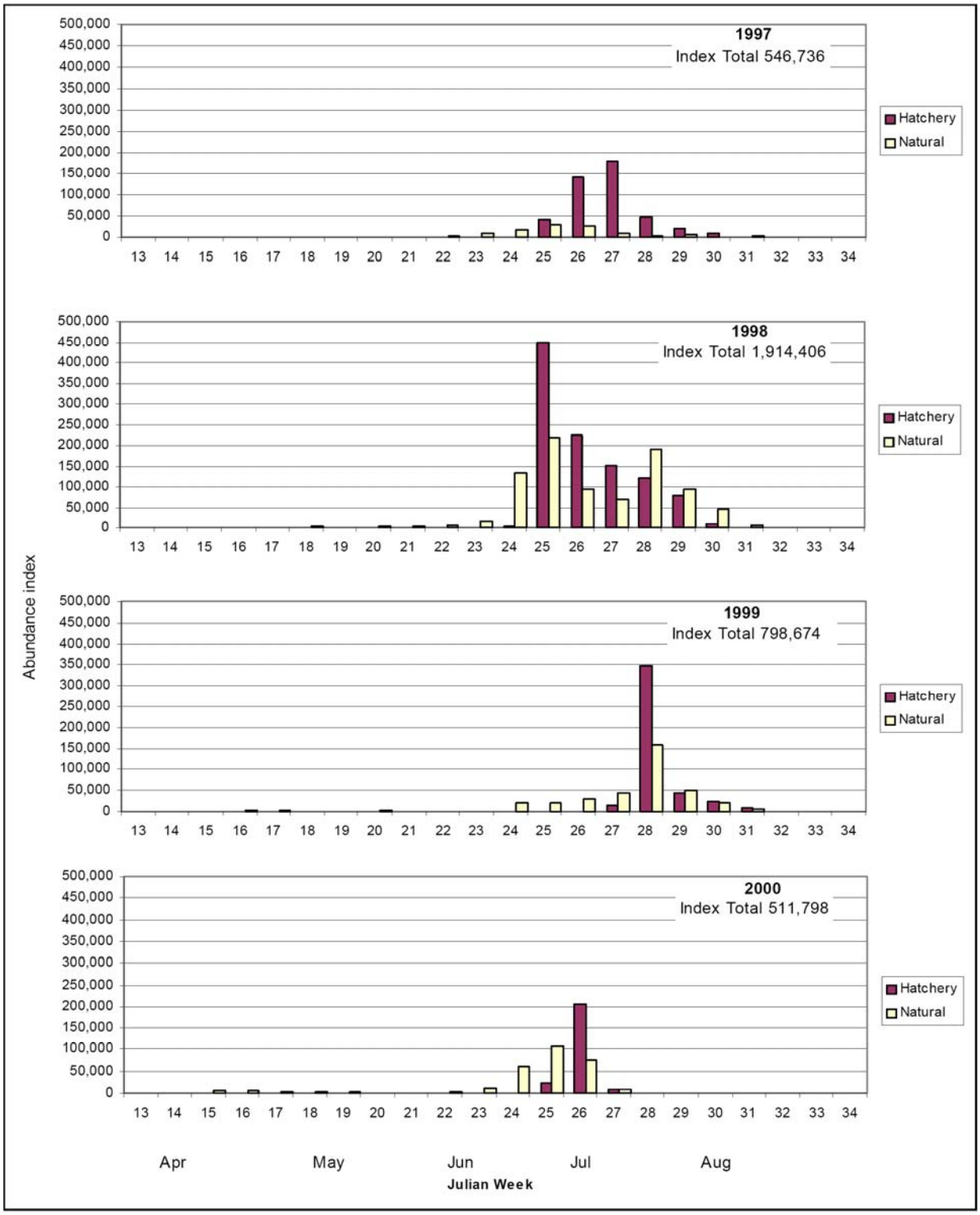

Figure 3-64. Weekly abundance index for natural and hatchery fall Chinook smolts during screw-trap sampling conducted at Big Bar (RM 49.7) on the Klamath River, 1997-2000. (Source: Scheiff et al., 2001)

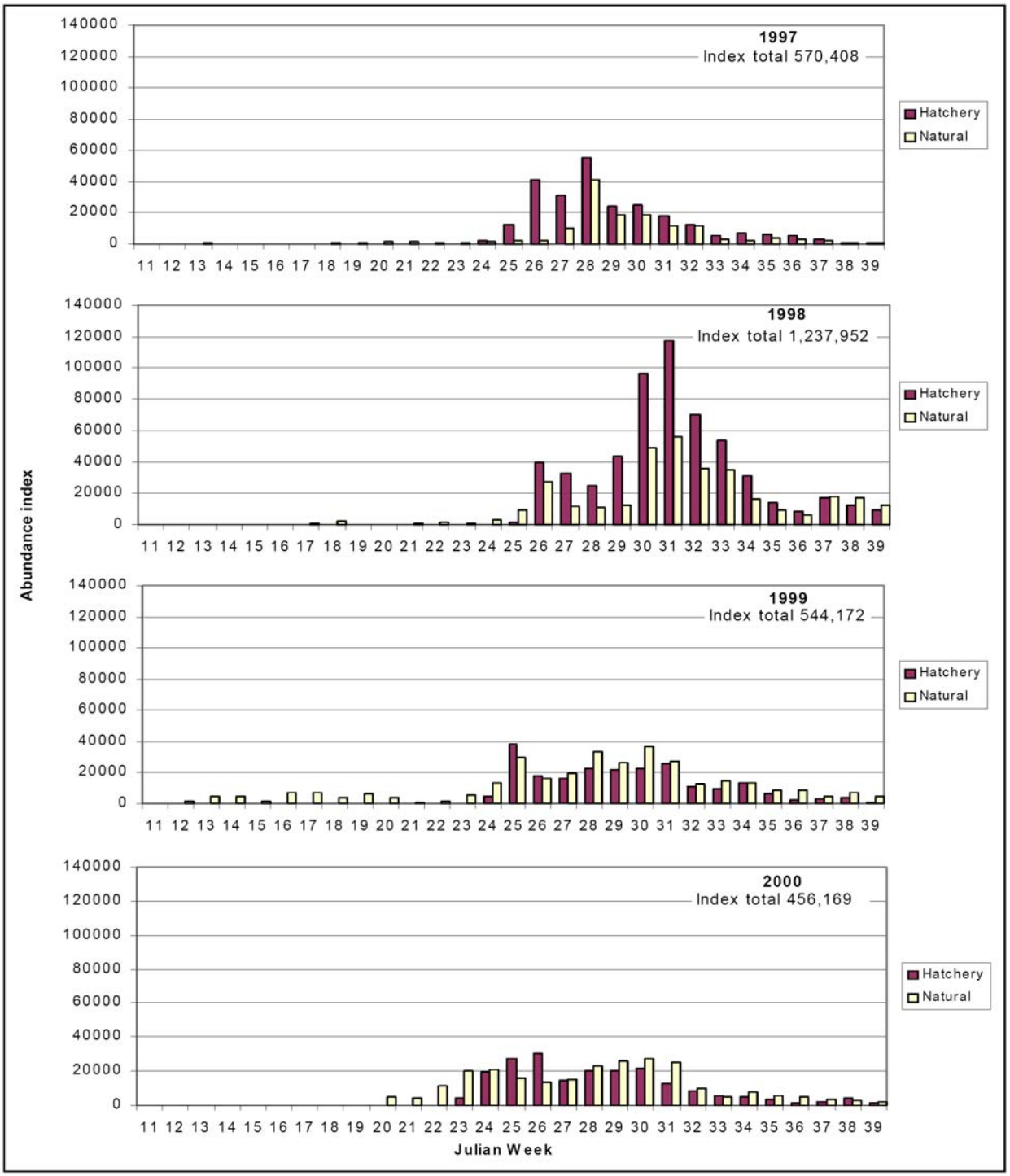

Figure 3-65. Weekly abundance index for fall Chinook smolts during screw-trap sampling conducted at Willow Creek (RM 21.1) on the Trinity River, 1997-2000. (Source: Scheiff et al., 2001)

Spring Chinook Salmon

As noted in the preceding section, spring Chinook salmon may have been the dominant run in the tributaries upstream of Upper Klamath Lake; NAS (2004) states that the spring run may have been nearly as abundant as the fall run in the basin overall. The Shasta, Scott, and Salmon rivers all supported large runs, but the spring runs suffered a precipitous decline in the 19th century due to the effects of hydraulic mining, dams, diversions, and fishing (Snyder, 1931). A large run in the Shasta River disappeared around the time that Dwinnell dam was constructed in 1926. In the Klamath River Basin upstream of the Trinity, only the Salmon River continues to support a run of spring Chinook salmon. As previously noted, returns to the Salmon River between 1980 and 2002 have ranged from 143 fish in 1983 to 1,443 fish in 1995 (see figure 3-60). Returns of spring Chinook salmon to the Trinity River between 1978 and 2002 have ranged from 1,315 fish in 1983 to 53,852 fish in 1988 (see figure 3-62). The Trinity run is supplemented by the annual release of approximately 1 million spring Chinook smolts each year from the Trinity hatchery. Although data shown in figure 3-62 indicate that returns to the hatchery constitute about a third of spring Chinook salmon run in the Trinity River, NAS (2004) suggests that all of the Trinity River mainstem spawners may be of hatchery origin.

Spring Chinook salmon exhibit a stream-type life history, meaning that the juveniles remain in streams for a year or more before they migrate to the ocean. Adult spring Chinook salmon typically enter freshwater before they are sexually mature, and hold in deep pools for 2 to 4 months before spawning. In California, this strategy allows salmon to spawn and develop in upstream reaches of tributaries that may be inaccessible to fall Chinook salmon because of low flows and higher temperatures in lower reaches during the summer and fall (Moyle, 2002).

Spring Chinook salmon enter the Klamath system from April through July (NAS, 2004). Ideal holding water temperatures for spring Chinook salmon are between 6 and 14°C, as temperatures above 14°C can reduce egg viability, and susceptibility to disease is reported to increase when water temperature exceeds about 16°C (McCullough, 1999). However, spring Chinook salmon in the Salmon River hold in pools where water temperatures often exceed 20°C (West, 1991), indicating that they are capable of surviving at higher water temperatures for short time periods. Spawning peaks in October. Fry emerge from the redds from March to early June, and they reside through the summer in cool headwater streams. Some juveniles may move downstream to the estuary as temperatures decline in October, although most do not migrate until the following spring (Hardy and Addley, 2001).

Coho Salmon

Coho salmon are thought to have once been abundant and widely distributed in the Klamath River and its tributaries, although their historical numbers and the extent of their upstream distribution is unknown due to uncertainty regarding species identification in historical reports and the dominance of the fishery for Chinook salmon (Snyder, 1931; NAS, 2004). Snyder (1931) reported that coho salmon may have migrated into the tributaries upstream of Upper Klamath Lake. Hamilton et al. (2005) note that early reports on the distribution of salmon in the Klamath River did not clearly differentiate between Chinook and coho salmon; usage of tributaries by coho salmon was documented as far upstream as Jenny and Fall creeks; and based on knowledge of the types of habitat preferred by the species, they concluded that coho salmon would probably have used Spencer Creek, which now flows into the upper part of the J.C. Boyle reservoir at RM 227.6. NMFS (2002) have identified important coho salmon habitat in the Shasta, Scott, Salmon, and Trinity rivers; in 6 creeks between Iron Gate dam and Seiad Valley; 13 creeks between Seiad Valley and Orleans; and 27 creeks between Orleans and the mouth of the Klamath.

Coho salmon populations in California in general and in the Klamath River Basin specifically have declined dramatically in the last 50 years (Cal Fish & Game, 2002a). Surveys in 2001 indicated that 17 (68 percent) of 25 historical coho salmon streams in the Klamath River Basin contained small numbers of juvenile coho salmon (Cal Fish & Game, 2002a). In the Trinity River, hatchery-produced coho salmon

have been estimated to comprise 97 percent of in-river spawners, with wild-produced fish comprising an average of only 200 fish out of a total average return of 10,190 adult coho salmon (FWS and Hoopa Valley Tribe, 1999). The number of adult coho salmon observed passing the Shasta fish counting weir have ranged from 0 to about 900 fish between 1930 and 2002, and less than 20 spawners were counted each year from 1985 through 1998 (see figure 3-58). More recently, counts at the Shasta weir have rebounded slightly, to 291 fish in 2001 and 86 fish in 2002. As noted previously, the counting facility is operated primarily during the Chinook salmon spawning run, so these counts do not include the later portion of the coho salmon run in most years.

NMFS considers naturally spawned coho salmon in the Klamath River Basin to be part of the Southern Oregon/Northern California Coasts coho salmon ESU. This ESU was listed as threatened on May 6, 1997 and critical habitat downstream of Iron Gate dam was designated on May 5, 1999. Additional information on the listing status and abundance trends within this ESU is provided in section 3.3.5, *Threatened and Endangered Species*.

Coho salmon in the Klamath River Basin spend the first 14 to 18 months of their lives in freshwater, after which the fish live in the ocean until they return to freshwater to spawn at the age of 3 years (NAS, 2004). Adults typically start to enter the river in September, peak migration occurs between late October and the middle of November, and a few fish continue to enter the river through the middle of December (NAS, 2004). Most spawning takes place in tributaries, but coho salmon have been observed spawning in side channels, tributary mouths, and shoreline margins of the mainstem Klamath River between Beaver Creek (RM 161) and Independence Creek (RM 94) (T. Shaw, M. Magnusen, A. Olsen, personal communication, as cited by Trihey & Associates, 1996). Fry start emerging in late February and typically reach peak abundance in March and April, although fry-sized fish appear into June and early July (Cal Fish & Game, 2002a). Fry are not territorial and have a tendency to move around; some fry are captured in outmigrant traps at the mouths of the Shasta and Scott rivers from March through May (Chesney and Yokel, 2003). Typical juvenile habitat consists of pools and runs in forested streams where there is dense cover in the form of logs and other large, woody debris.

Preferred coho salmon rearing temperatures are from 12 to 14°C (Bell, 1991), although juvenile coho salmon can, under some conditions, live at 18 to 29°C for short periods (McCullough, 1999; Moyle, 2002). Early laboratory studies in which juvenile coho salmon were reared under constant temperatures indicated that exposure to temperatures over 25°C, even for short periods, should be lethal (Brett, 1952). In laboratory studies where temperatures were increased gradually (1°C/hr), lethal temperatures were found to range from 24 to 30°C, depending on the temperature to which the fish were originally acclimated (McCullough, 1999).

NAS (2004) reports that juvenile coho salmon can survive and grow at high daily maximum temperatures provided that (1) food of high quality is abundant so that foraging uses little energy and maximum energy can be diverted to the high metabolic rates caused by high temperatures, (2) refugia areas of low temperature are available so that exposure to high temperatures is not constant, and (3) competitors or predators are largely absent so that the fish are not forced into physiologically unfavorable conditions or energetically expensive behavior (such as aggressive interactions). Snorkel surveys conducted at temperature refugia (tributary-mouth pools) in the Klamath River conducted in 2001, however, indicate that the proportion of refugia occupied by juvenile coho salmon decreased from 16 percent in June to 3 percent (a single pool) in August and September (table 3-51). Most of the tributary mouth pools contained juvenile Chinook salmon, steelhead, or both. These fishes can compete with and prey on juvenile coho salmon (and each other) and are somewhat more tolerant of high temperatures than coho salmon.

Table 3-51. Pools containing juvenile coho salmon, Chinook salmon, and steelhead on the mainstem Klamath River in 2001, as determined in snorkeling surveys.[a] (Source: NAS, 2004)

Months of Survey	No. of Months Pools Surveyed	No. (%) of Pools with Juvenile Fish		
		Coho Salmon	Chinook Salmon	Steelhead
June	31	5 (16)	26 (84)	26 (84)
July	46	7 (15)	41 (89)	43 (93)
August	39	1 (3)	26 (67)	34 (87)
September	32	1 (3)	13 (41)	28 (88)

[a] The data are comprehensive in that they include all tributaries large enough to form a cool pool, and include some tributaries below the Trinity River (e.g., Blue Creek).

Juvenile coho salmon transform into smolts and begin migrating downstream in the Klamath River Basin between February and the middle of June (NAS, 2004). Most smolts captured in the screw trap at Big Bar are taken between mid-April and mid-June (figure 3-66). Smolts may feed and grow in the estuary for a month or so before entering the ocean. Once at sea, they spend the next 18 months or so as immature fish that feed voraciously on shrimp and small fish, and grow rapidly.

Steelhead

Historically, the Klamath River supported large populations of steelhead, the anadromous form of rainbow trout. Steelhead were distributed throughout the mainstem and the principal tributaries such as the Shasta, Scott, Salmon, and Trinity River basins, and many of the smaller tributary streams. Steelhead also were likely distributed in the tributaries upstream of Upper Klamath Lake, but due to difficulty in differentiating steelhead from large resident rainbow trout, precise information on the upstream limit of their distribution is lacking. Hamilton et al. (2005) note that, in watersheds where both Chinook salmon and steelhead are present, the range of steelhead is usually the same, if not greater.

Hardy and Addley (2001) state that, before 1900, runs of steelhead in the Klamath River Basin may have exceeded several million fish. They cite more recent run size estimates of 400,000 fish in 1960; 250,000 in 1967; 241,000 in 1972; and 135,000 in 1977. In its most recent status review for the Klamath Mountains province steelhead ESU, NMFS (2001) indicates that most California populations showed a precipitous decline to very low abundance around 1990 and stayed at low levels through 1999, but a modest increase in abundance was noted in 2000. Escapement estimates of summer steelhead to the Salmon River (see figure 3-61) are consistent with the trend noted by NMFS, and in the Salmon River this increasing trend continued in 2002. The increased return of summer steelhead from 2000 to 2002 coincides with a period of strong returns of adult salmon and steelhead to the region caused by favorable ocean conditions that existed between 1998 and 2001. Information on the abundance of winter steelhead, which is considered to be the most abundant form, is very limited due to logistical difficulties in sampling adults during the winter season (NMFS, 2001).

NMFS considers all steelhead in the Klamath River Basin to be part of the Klamath Mountains province ESU. Moyle (2002) describes two life history forms within this ESU, a summer run and a winter run. Hopelain (1998), however, concluded that there are three distinct runs of steelhead in the Klamath River Basin: a winter run that enters the river from November through March, a spring run that enters the river from March through June, and a fall run that enters the river from July through October. Other reports appear to consider the fall run described by Hopelain to be a component of the winter run, based on a run timing of August through February given for winter-run steelhead by Barnhart (1994; as cited by NAS, 2004). After entering the river, winter-run steelhead disperse throughout the lower basin and spawn mainly in tributaries but also show some mainstem spawning. Spawning, which can take place any time from January through April, apparently peaks in February and March (NAS, 2004).

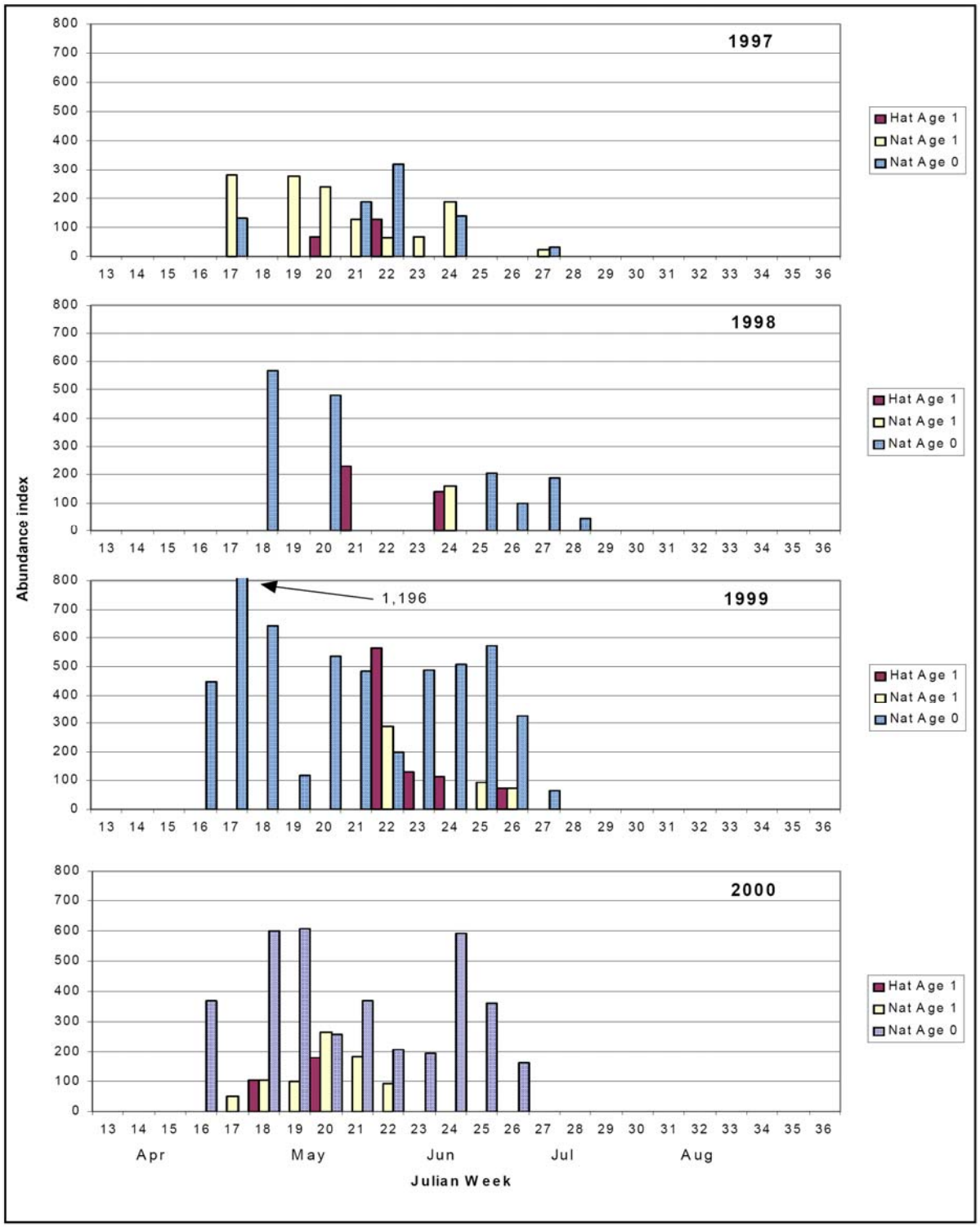

Figure 3-66. Weekly abundance index for natural and hatchery coho salmon smolts during screw-trap sampling conducted at Big Bar (RM 49.7) on the Klamath River, 1997-2000. (Source: Scheiff et al., 2001)

According to Moyle (2002), summer-run steelhead migrate upstream to the cool waters of the larger tributaries from late April through June. They typically hold in deep pools until December, when they spawn. Maximum daytime temperatures of less than 16°C seem to be optimal (NAS, 2004), although Nakamoto (1994) reported steelhead holding in deep pools in the New River, California, in water temperatures that ranged from 16.8 to 24.6°C over a 27-day period during late July to early August.

Steelhead fry emerge from the gravel in the spring, and most spend 2 years in fresh water before going to sea. The rest spend either 1 or 3 years in fresh water (Hopelain, 1998). Juvenile steelhead occupy virtually all accessible habitats in which conditions are physiologically suitable. Although spawning occurs mainly in tributaries, the juveniles distribute themselves widely, and many move into the mainstem. Juveniles feed primarily on invertebrates, especially drifting aquatic and terrestrial insects, but fish (including small salmon) can be an important part of the diet of larger individuals. Aggressive 2-year-old steelhead (6 to 7 inches) often dominate in pools (NAS, 2004).

Both resident and anadromous forms of rainbow trout exhibit a high degree of thermal tolerance compared to most other salmonids. Preferred temperatures are usually from 15 to 18°C, but juvenile rainbow trout regularly persist in water where daytime temperatures reach 26 to 27°C (Moyle, 2002). Long-term exposure to temperatures that are continuously above 24°C, however, is usually lethal. Steelhead cope with high temperatures by finding thermal refugia or by living in areas where nocturnal temperatures drop below the threshold of stress (NAS, 2004). Persistence in thermally stressful areas requires abundant food. Smith and Li (1983, as cited by NAS, 2004) found that juvenile steelhead persisted in a small California stream in which daytime temperatures sometimes reached 27°C for short periods by moving into riffles where food was abundant.

Migrant sampling conducted from 1997 through 2000 at Big Bar on the Klamath River (RM 49.7) and at Willow Creek on the Trinity River (RM 21.1) indicates that the peak outmigration of steelhead smolts occurs from early April through mid- June in both rivers, with smaller numbers of steelhead smolts continuing to migrate through September, especially in the Trinity River (Scheiff et al., 2001). A majority of Klamath steelhead return to fresh water as "half-pounders," 3 to 4 months after their initial entry into salt water. This life-history trait allows steelhead to consume eggs from the large numbers of Chinook salmon that enter the river in the fall (NAS, 2004). Half-pounders usually stay in the lower mainstem of the Klamath through March before they return to the sea to mature. Klamath steelhead spend 1 to 4 winters in the ocean before they return to spawn. About 30 percent of the steelhead in the Klamath spawn a second time after another year at sea, and about 5 percent survive to spawn a third time (Hopelain, 1998).

Green Sturgeon

Green sturgeon are an anadromous species that is known to range in nearshore marine waters from Mexico to the Bering Sea. NMFS has identified two distinct population segments: a northern coastal segment consisting of populations spawning in coastal watersheds northward of and including the Eel River[67] and a southern segment consisting of coastal or Central Valley populations spawning in watersheds south of the Eel River. The Klamath River Basin supports the largest spawning population of the species, which is included in the northern DPS and also includes fish that spawn in Umpqua, Rogue, and Eel rivers. On April 6, 2005, NMFS proposed to list the southern DPS as threatened and determined that the northern DPS does not warrant listing, but it maintained the northern DPS on the species of concern list due to remaining uncertainties about its status and threats.

Green sturgeon enter the Klamath River to spawn from March through July (NAS, 2004). Most spawning occurs from the middle of April to the middle of June. Spawning takes place in the lower mainstems of the Klamath and Trinity rivers in deep pools with strong bottom currents. As noted

[67]The Eel River enters the Pacific Ocean near Eureka, about 50 miles south of the Klamath River.

previously, green sturgeon have been observed migrating into the Salmon River, but they are not thought to ascend the Klamath River beyond Ishi Pishi Falls (RM 66)(Moyle, 2002; NMFS, 2005). Juveniles stay in the river until they are 1 to 3 years old, when they move into the estuary and then to the ocean. Optimal temperatures for juvenile growth appear to be from 15 to 19°C, and temperatures above 25°C have been reported to be lethal (Mayfield, 2002, as cited by NAS, 2004). Outmigrant juveniles are captured each year in screw traps at Big Bar (RM 49.7) on the Klamath River and at Willow Creek (RM 21.1) on the Trinity River (Scheiff et al., 2001). After leaving the river, green sturgeon spend 3 to 13 years at sea before returning to spawn, and they often move long distances along the coast (NAS, 2004).

Green sturgeon support small tribal fisheries by the Yurok Tribe in the Klamath River and the Hoopa Valley Tribe in the Trinity River (table 3-52). Although Yurok and Hoopa Valley tribal catch has remained relatively constant in recent years, commercial and sport harvest has been greatly reduced by newly imposed fishing regulations in Oregon and Washington. Commercial fisheries targeting sturgeon have not been allowed in the Columbia River or in Willapa Bay, Washington, since 2001. In California, commercial fisheries for sturgeon are prohibited and regulations prohibiting the recreational harvest of green sturgeon took effect in March 2006.[68]

Pacific Lamprey

Pacific lamprey are found in Pacific coast streams extending from Alaska to Baja California. They currently occur throughout the mainstem Klamath River and its major tributaries downstream of Iron Gate dam. The extent of their historical upstream distribution is uncertain due to the occurrence of several resident species of lamprey in the upper parts of the basin. Hamilton et al. (2005) note that Pacific lamprey are capable of migrating long distances, and generally show a similar distribution as anadromous salmon and steelhead. In his September 27, 2006, decision, the ALJ concluded, however, that there is insufficient evidence in the record to determine whether Pacific lamprey historically were distributed above the present site of Iron Gate dam.

Pacific lamprey are anadromous nest builders that, like salmon, die shortly after spawning. They enter the Klamath at all times of the year and cease feeding as they migrate upstream. They spawn at the upstream edge of riffles in sandy gravel. Lamprey eggs hatch in approximately 2 to 4 weeks, and then the larvae (ammocoetes) drift downstream to backwater areas where they burrow into the substrate and commence feeding, tail embedded and head exposed, on algae and detritus. Juveniles remain in fresh water for 5 to 7 years before they migrate to the sea at a length of about 6 inches and transform into adults (Moyle, 2002). They spend 1 to 3 years in the marine environment, where they parasitize a wide variety of ocean fishes, including Pacific salmon, flatfish, rockfish, and pollock. Their degree of fidelity to their natal streams is unknown (FWS, 2004a). Adult Pacific lamprey typically range between 30 and 76 centimeters (12 and 30 inches) in length (Moyle, 2002).

Larson and Belchik (1998) interviewed 20 Yurok tribal elders about the historic and current lamprey fishery in the Klamath River. Most of those interviewed reported daily catches as high as 300 to 1,500 lamprey per person per day before the run declined some time between the late 1960s and the late 1980s. Reported catches since the decline have not exceeded 100 fish, with most respondents indicating that a catch of 20 lamprey was considered an extremely good catch. Pacific lamprey are collected regularly in screw traps fished in the Klamath at Big Bar and in the Trinity River at Willow Creek (see table 3-51).

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[68]Cal Fish & Game News release on emergency sturgeon regulations http://www.dfg.ca.gov/news/news060630.html accessed on June 16, 2006.

Table 3-52. Harvest of green sturgeon from California, Oregon, and Washington from 1985 to 2003. (Source: NMFS, 2005)

	California			Oregon					Washington							
		Klamath				Columbia River		Willapa Bay			Greys Harbor					
Year	**SF Bay**	**Yurok**	**Hoopa**	**Sport**	**Trawl**	**Sport**	**Comm.**	**Comm.**	**Sport**	**Treaty**	**Comm.**	**Sport**	**Treaty**	**Trawl**	**Other Treaty**	**Total**
1985	Few	351	10		726	533	1,600	1,289			227		5	348	67	5,156
1986	Few	421	30	153	190	407	6,000	925		1	626		3	142	167	9,065
1987	Few	171	20	170	124	228	4,900	877			770		8	52	349	7,669
1988	Few	212	20	258	120	141	3,300	1,598	4		609	4	1	34	213	6,514
1989	Few	268	30	202	210	84	1,700	461	4		870	12	2	133	91	4,067
1990	Few	242	20	157	143	86	2,200	953	2		734	4	9	66	120	4,736
1991	Few	312	11	366	242	22	3,190	957	0		1,527	0	3	99	59	6,788
1992	Few	212	3	197	94	73	2,160	1,002	0		737	0	3	66	4	4,551
1993	Few	417	36	293	250	15	2,220	290	32		542	112	3	37	20	4,267
1994	Few	293	6	160	154	132	240	268	13	6	17	25	22	5	1	1,342
1995	Few	131	6	78	29	21	390	78	8		374	96	7	3	65	1,286
1996	Few	119	8	210	182	63	610	129	24		137	70	132	1	7	1,692
1997	Few	306	16	158	400	41	1,614	16	4		316	105	198	6	19	3,199
1998	Few	335	10	103	77	73	894	65	12	2	25	28	55	0		1,692
1999	Few	204	28	73	21	93	967	9	5		0	29	58	4		1,491
2000	Few	162	31	15	12	32	1,224	224	5		0	38	50	3		1,796
2001	Few	268	10	NA	17	50	342	106	9		0	27	32	1		862
2002	Few	273	5	NA	14	51	163	0	48		7	0	131	4		696
2003	Few	287	16	NA	17	52	46	43	NA		2	NA	46	5		514
2004			12	NA												

Eulachon

The eulachon or candlefish is a smelt that reaches the southern extent of its range in the Mad River, Redwood Creek, and the Klamath River (Moyle, 2002). Historically, large numbers entered the river to spawn in March and April, but they rarely moved more than 8 miles inland (NAS, 2004). Spawning occurs in gravel riffles, and the embryos take about a month to develop before hatching. Upon hatching, the larvae are washed into the estuary. The eulachon in the Klamath River once was an important food of the Native Americans in the region (Trihey & Associates, 1996). Moyle (2002) states that eulachon have been scarce in the Klamath River since the 1970s, with the exception of 3 years: they were plentiful in 1988 and moderately abundant again in 1989 and 1999. Based on interviews with Yurok tribal elders, Larson and Belchik (1998) state that most tribal fishers perceived a decline in the mid to late 1970s, although a smaller number thought that it was in the 1980s. Similar declines have been noted elsewhere within the species range. Commercial landings in the Columbia River and its tributaries averaged between 1 and 3 million pounds prior to 1993, but declined ten-fold starting in 1994 (figure 3-67). A similar decline has occurred in the Fraser River, where landings decreased from about 100 metric tons (110 tons) prior to 1966 to about 20 metric tons (22 tons) in the early 1990s, leading to closure of the fishery in 1998, 1999, and 2000.[69]

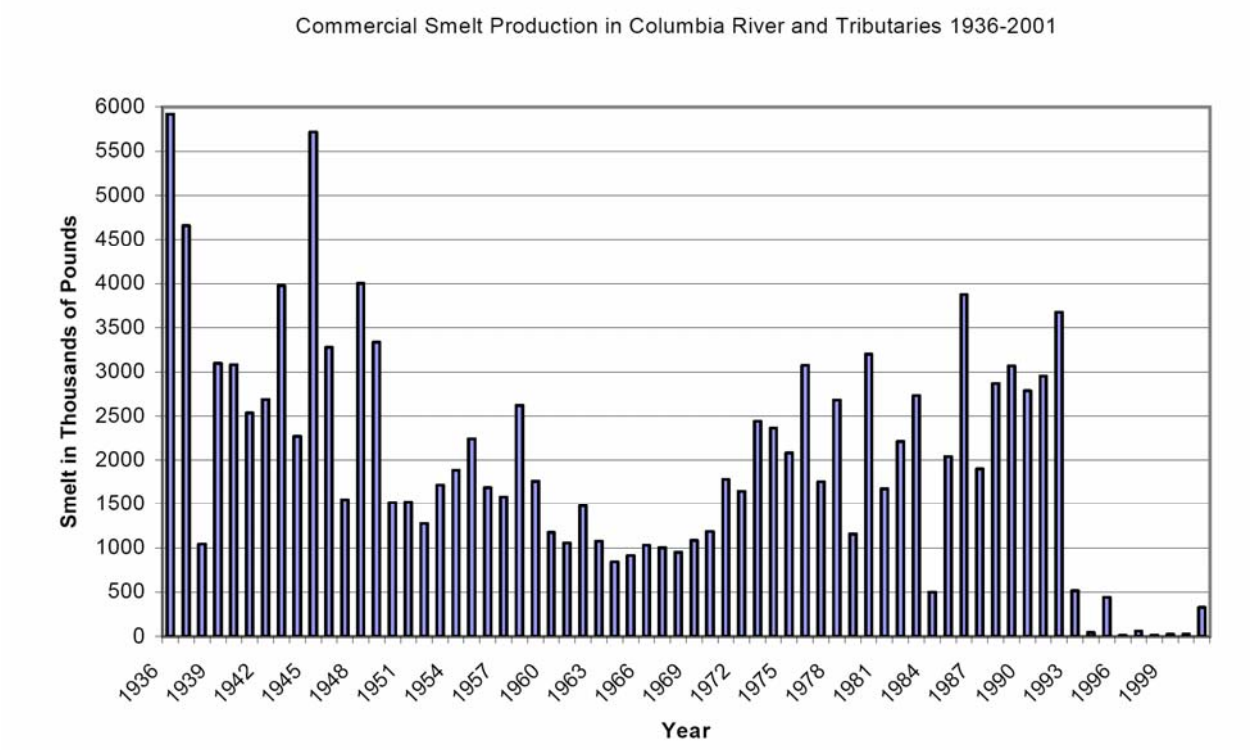


Figure 3-67. Eulachon commercial landings in the Columbia River and tributaries, 1936 to 2001. (Source: Accessed from http://www.nwcouncil.org/fw/subbasinplanning/lowerColumbia/plan/2004_05/TechnicalFoundation/VolumeIII/Vol.%20III%20Ch.%204--Eulachon.pdf on January 2, 2006)

[69]Fraser river catch records accessed from http://www.pac.dfo-mpo.gc.ca/ops/fm/herring/eulachon/default_e.htm on January 2, 2006.

Other Anadromous Species

NAS (2004) reports that coastal cutthroat trout occur mainly in the smaller tributaries of the Klamath River within about 22 miles of the estuary; this species also has been observed further upstream in tributaries to the Trinity River (Moyle et al., 1995). Sea-run adults enter the river for spawning in September and October, and juveniles rear in fresh water for 1 to 3 years before going to sea during April through June.

Other anadromous fish species that occur in the Klamath River Basin include chum salmon, white sturgeon, and American shad. NAS (2004) reports that periodic observations of adult chum salmon and regular collection of small numbers of young suggest that this species continues to maintain a small population in both the Klamath and Trinity rivers, though it has never been present in large numbers.

3.3.3.1.3 Trinity and Iron Gate Hatcheries

Trinity Hatchery

The Trinity River Hatchery, located at the base of Lewiston dam, began operation in 1963 to compensate for salmon and steelhead spawning and rearing habitat losses upstream of Lewiston dam and farther upstream above Trinity dam. Trinity River Hatchery produces spring and fall Chinook salmon, coho salmon, and steelhead.

Trinity River Hatchery releases approximately 1 million juvenile spring Chinook salmon and roughly 1 to 3 million juvenile fall Chinook salmon each year. Releases usually occur in late May to early June, with fish reaching the estuary 1 to 2 months later (NAS, 2004). The Trinity River run of up to several thousand adult spring Chinook salmon each year apparently consists primarily of returning Trinity River Hatchery fish (NAS, 2004). In addition, approximately one-third of the adult Chinook salmon fall run in the Trinity River is reported to consist of returning Trinity River Hatchery fish (NAS, 2004).

The Trinity River Hatchery also produces coho salmon and winter steelhead. The hatchery has released an average of about 525,000 coho salmon smolts per year in recent years (NAS, 2004). Coho salmon smolts are released between about mid-March and early May and reach the estuary at the same time as wild smolts, peaking in late May and early June. About 800,000 winter-run steelhead smolts are produced each year. Steelhead smolts are released in late March, and most of them reach the estuary in late April along with wild steelhead smolts (NAS, 2004). NAS (2004) suggests that the run of coho salmon to the Trinity River is likely dominated by hatchery-produced fish, while hatchery-produced steelhead have comprised from 20 to 34 percent of steelhead runs in the Trinity.

Iron Gate Hatchery

The Iron Gate Hatchery was built in 1961 as mitigation for the loss of spawning areas in the Klamath River and its tributaries between the Iron Gate and Copco developments. The adult salmon ladder, trap, and spawning facility were built at the base of the dam and put into operation in 1962. The hatchery complex, including egg incubation, rearing, maintenance, and administration facilities, as well as staff residences, was constructed about 400 yards downstream in March 1966. The current production goals and release dates for fall Chinook and coho salmon and steelhead are presented in table 3-53.

Table 3-53. Iron Gate Fish Hatchery production. (Source: Hampton, 2005, adapted by staff)

Species	Type	Number	Target Release Dates[a]	Adult Run Timing
Fall Chinook Salmon	Subyearling	4,920,000[b]	May-June	September-November
	Yearling	1,080,000[c]	November	September-November
Coho Salmon	Yearling	75,000	March	Late October-early January
Steelhead	Yearling	200,000	March-May	January-November

[a] If unusual circumstances dictate, releases may deviate from the target release dates on approval from the regional manager.

[b] In years when yearlings are not reared at the Fall Creek rearing facility, the smolt production will be 5,100,000.

[c] Approximately 900,000 shall be reared at Iron Gate Hatchery and 180,000 shall be reared at the Fall Creek ponds and released from Iron Gate fish hatchery. If the Fall Creek rearing facility is not operated, the production goal shall be 900,000 yearlings.

In response to recommendations by the Joint Hatchery Review Committee (2001), Cal Fish & Game implemented an early release strategy for Chinook salmon, whereby subyearling smolts are released beginning in May in four groups, each separated by about 1 week. The benefits of such a release strategy are currently under investigation, but the premise is that it may reduce competition with natural salmonids, and possibly increase smolt survival due to the presence of lower temperatures and higher flows during the time of the release (Hampton, 2005).

Cal Fish & Game operates Iron Gate Hatchery, and PacifiCorp funds 80 percent of the total operating costs to satisfy its annual mitigation goals for fall Chinook salmon fingerlings, coho salmon yearlings, and steelhead yearlings. Beginning in 1979, portions of the fall Chinook salmon fingerling production have been reared to the yearling stage for release in November. This yearling program was funded entirely by Cal Fish & Game. Yearling production at the Fall Creek rearing facility has recently been terminated due to a lack of state funding, and the funding for yearling production at Iron Gate is determined on a yearly basis.

Current production at Iron Gate Hatchery maximizes use of the facilities, with six of eight raceways dedicated to Chinook salmon production, and one each for coho salmon and steelhead. In years when Cal Fish & Game funds Chinook salmon yearling production, the Fall Creek facility is used for rearing about 200,000 Chinook salmon to the yearling stage, with survival to release typically 180,000 fish at 8 fish/lb. Current production uses 30 cfs for incubation and rearing, with up to 50 cfs used on occasion, mostly when the fish ladders are operational. The 30 cfs in the rearing facility are fully used during subyearling smolt releases (and smolt transfer) and during yearling releases. Water used to support current production at Iron Gate comes from high and low-level intakes at Iron Gate reservoir. From late spring through early fall, water for the raceways and upper ladder is supplied from the 70-foot deep intake at Iron Gate. This supply of cool water from below the thermocline is limited, and in some years is depleted by late summer such that warm water temperatures have caused substantial mortalities of adult Chinook salmon in the pre-spawning holding ponds (PacifiCorp, 2005k). At the Fall Creek rearing facility, Cal Fish & Game diverts and uses 6 to 9 cfs from the Fall Creek powerhouse tailrace channel. Flows are returned back to the creek.

For all species cultured, only fish that volitionally enter the hatchery are used as brood stock. Generally, this has been the practice since the hatchery began operation. However, there were 4 years when coho salmon returns to the hatchery were low to the point where eggs were imported. In 1966, 1967, 1968, and 1970, the majority of coho salmon production (60 to 70 percent) at Iron Gate was from eggs imported from the Cascade Hatchery on the Columbia River.

The annual egg allotment for all species is distributed throughout the duration of the spawning run in proportion to the instantaneous magnitude of the run. Maintaining genetic diversity by distributing

the egg allotment throughout the spawning run takes precedence over meeting numeric production goals. Wild spawners are commonly integrated into the hatchery egg take to minimize genetic digression between hatchery and wild stocks. All adult steelhead processed in the hatchery are returned to the river, and all juvenile salmon and steelhead that are produced are released directly into the Klamath River from the hatchery.

Figures 3-68, 3-69, and 3-70 show the historical production of juvenile fish at Iron Gate Hatchery from 1965 to 2001 for fall Chinook salmon, coho salmon, and steelhead, respectively. Coho salmon and steelhead fingerling releases were discontinued for the most part in the early 1980s.

Chinook salmon production fluctuated substantially in the years preceding 1989. Numbers of Chinook salmon smolts ranged from 454,546 in 1965 to 12,727,288 in 1985. The period from 1977 through 1984 had relatively low production, well below production goals. Production exceeded goals from 1985 through 1988, and has been consistently at or close to goals since 1989.

Coho salmon production has varied from zero to 200,000 yearling smolts. The production goal of 75,000 yearlings has been met in 26 of the last 37 years, or 70 percent of the time. Production was frequently below the production goal during the 1970s. Production in the 1980s was usually above this target, with much greater numbers in the late 1980s. Since 1994, production has been maintained close to production goals. Fingerling releases were made periodically before 1984 and were relatively large in 1969 and 1982, corresponding to relatively large adult returns.

Steelhead production has varied widely through the years ranging from a high of 642,857 yearlings in 1970 to a low of 10,702 in 1997. Production has declined steadily since the peak year in 1970, and the production goal of 200,000 smolts has not been met since 1991. Fingerling releases have been made in past years, but not since 1988. During the 1980s, fingerling releases of 200,000 to 300,000 were common with a peak of one million fingerlings released in 1970.

Figure 3-71 shows returns of adult salmon and steelhead to the Iron Gate Hatchery from 1964 to 2002. The values shown do not include jacks (defined as fish less than 22 inches long). From 1963 to 1999, fall Chinook salmon returns to the hatchery ranged from 954 in 1969 to 22,681 in 1995, with a generally increasing trend. In 2000 and 2001, record numbers of Chinook salmon returned to Iron Gate Hatchery, with 71,151 returning in 2000.

Coho salmon returns have ranged from zero to 4,097, averaging 830 fish from 1963-2002 (see figure 3-71). Coho salmon returns to Iron Gate Hatchery have increased on average over the years, but with substantial variation between years. What has changed the most are the magnitude of the peak years, such as 1996/1997 when over 4,000 adult coho salmon returned to the hatchery. These peak years are interspersed with returns as low as a few hundred fish. Cal Fish & Game also reports (Hampton, 2005) that since 1997, the percentage of unmarked coho salmon entering the hatchery has ranged from 43.2 percent (1998) to 7.6 percent, averaging 21 percent. The unmarked coho salmon include wild coho, unmarked hatchery coho, and unmarked hatchery coho salmon from the Cole M. Rivers Hatchery on the Rogue River.

Steelhead returns have been erratic, but showed a precipitous decline in the early 1990s (see figure 3-71). Since 2000, the run has recovered somewhat. In 2003, the egg take met collection goals (200,000) for the first time in a decade with an adult return of 495 adult fish.

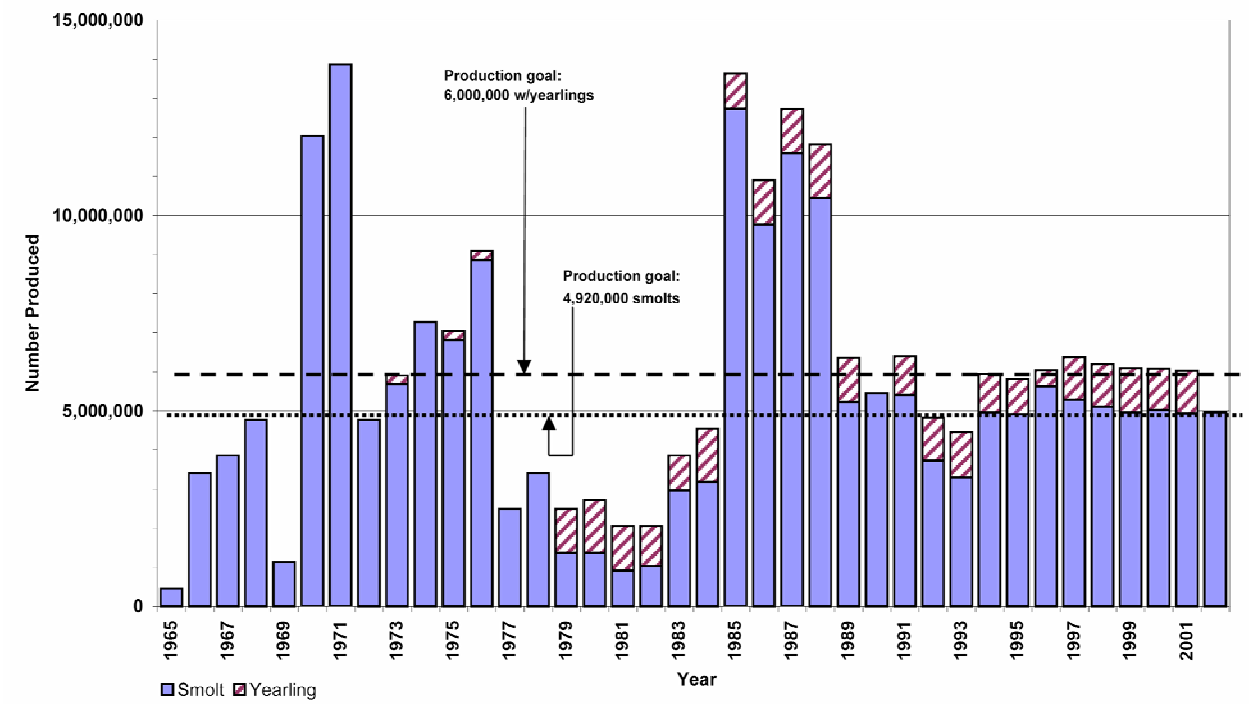


Figure 3-68. Fall Chinook salmon production at Iron Gate Hatchery, 1965 to 2001. (Source: PacifiCorp, 2004a)

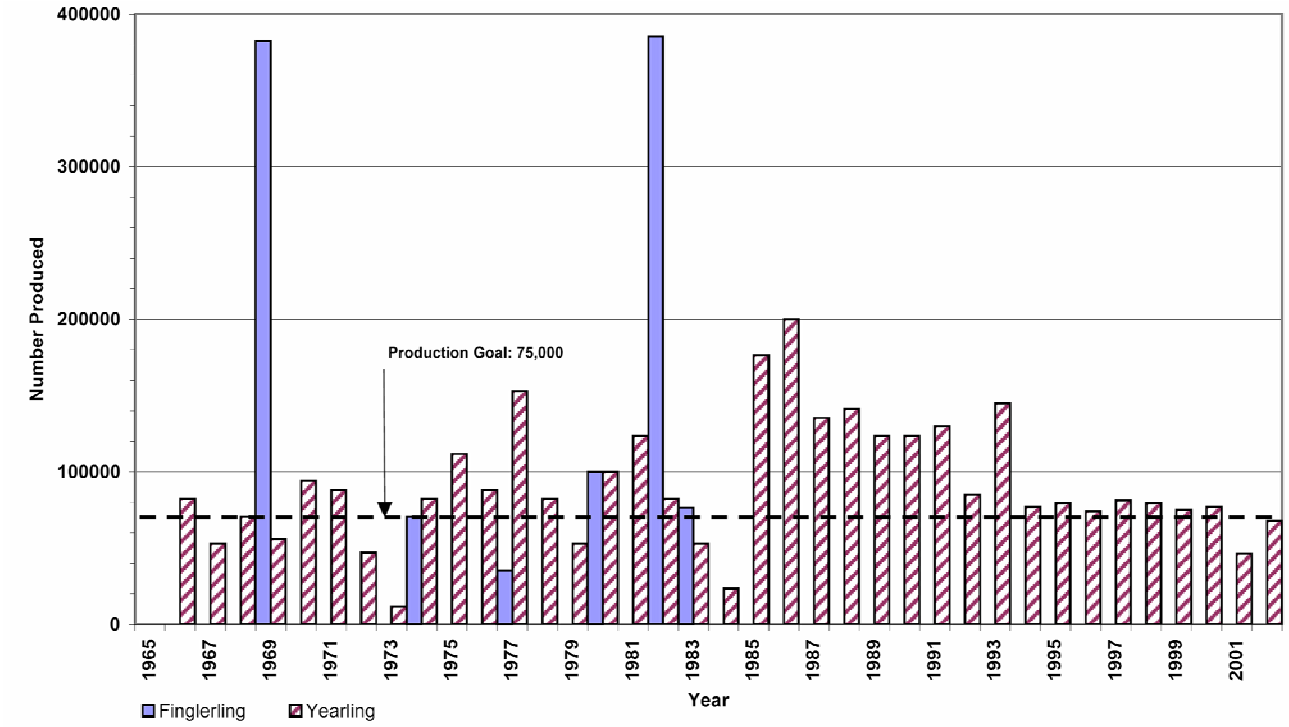


Figure 3-69. Coho salmon production at Iron Gate Hatchery, 1965 to 2001. (Source: PacifiCorp, 2004a)

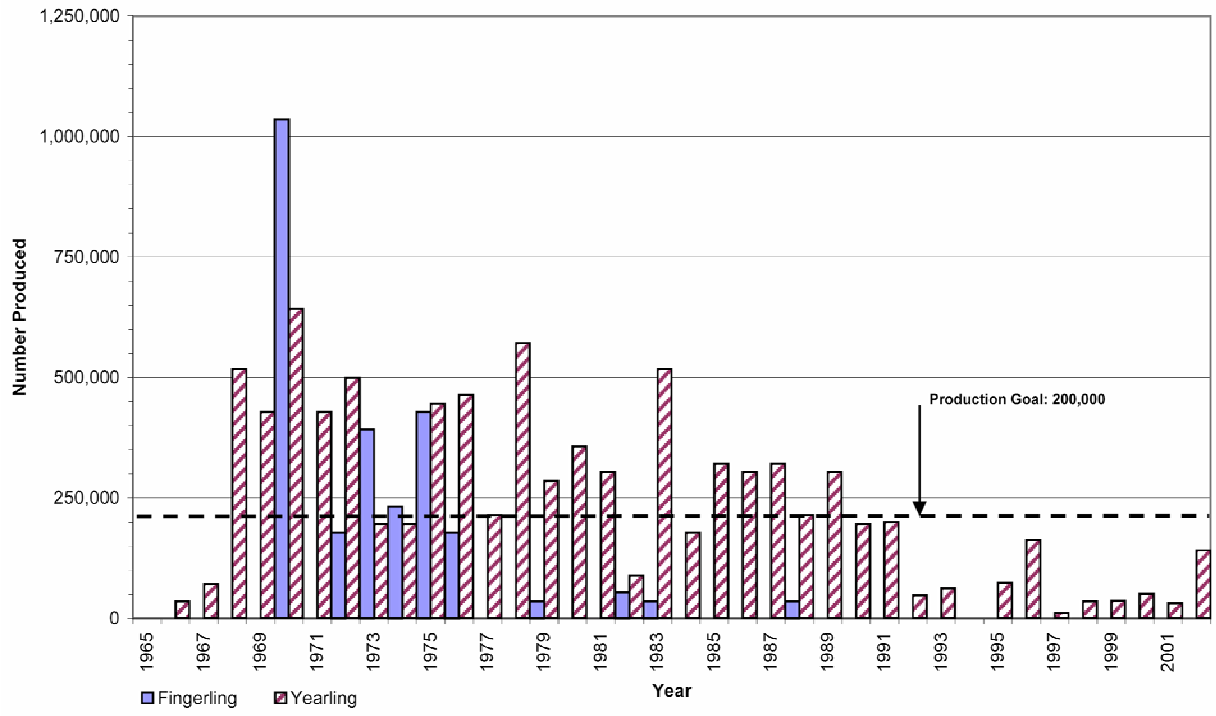


Figure 3-70. Steelhead production at Iron Gate Hatchery, 1965 to 2001. (Source: PacifiCorp, 2004a)

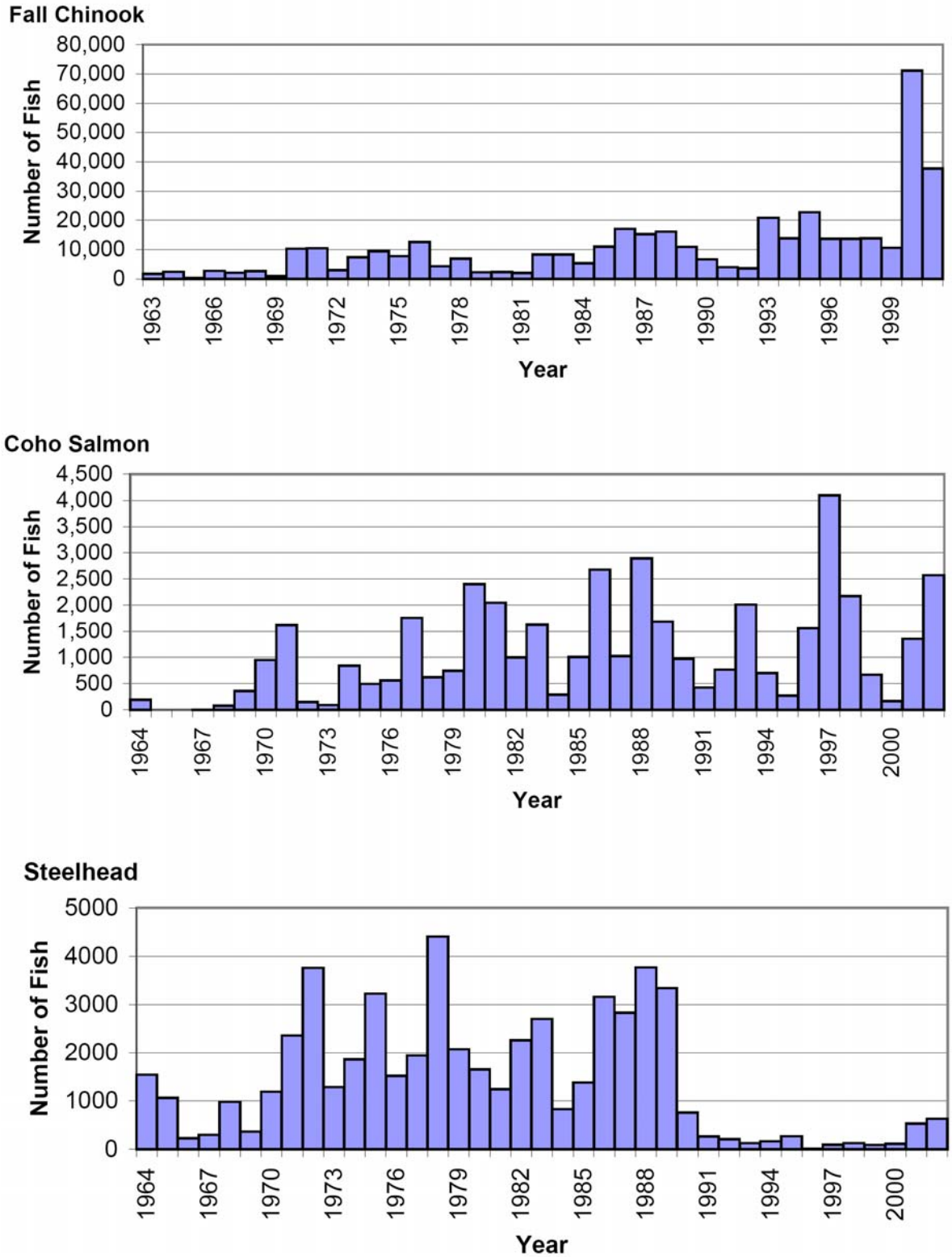


Figure 3-71. Adult salmon and steelhead returns to the Iron Gate Hatchery. (Source: PacifiCorp, 2004a)

3.3.3.1.4 Diseases Affecting Salmon and Steelhead

Juvenile Salmonids

Several pathogens have been identified that may contribute to losses of juvenile anadromous fish during their outmigration from the Klamath River Basin. Pathogens observed to cause disease in juvenile salmonids in the Klamath and Trinity rivers include *C. shasta*, *Flavobacterium columnare* (columnaris), Aeromonid bacteria, *Nanophyetus salmonicola*, and the kidney myxosporean *Parvicapsula minibicornis*. Ceratomyxosis, the disease caused by *C. shasta,* has been identified as the most significant disease for juvenile salmon in the basin (Nichols et al., 2003). Foott et al. (2002) found that over 40 percent of Chinook salmon smolts sampled from the lower Klamath River in 2001 were diagnosed with severe ceratomyxosis, and the incidence of *C. shasta* infection has ranged from 29 to 43 percent in juvenile Chinook salmon collected in the Klamath estuary (Foott et al., 2002; Nichols et al., 2003). Nichols and Foott (2005) estimated that 45 percent of the juvenile fall Chinook salmon that outmigrated in 2004 were infected with *C. shasta*, and 94 percent of the population was infected with *P. minibicornis*. They concluded that the high incidence of fish infected with both pathogens suggests that the majority of the *C. shasta* infected juvenile Chinook salmon would not survive. Monitoring results in 2005 reported by Nichols indicate that infection rates of juvenile fall Chinook salmon with *C. shasta* increased to levels that exceeded 70 percent by late April, and infection rates for *P. minibicornis* ranged between 94 and 100 percent from late April through at least mid-May (FWS memo undated. Accessed on the web, August 24, 2007, via: http://ncncr-isb.dfg.ca.gov/KFP/uploads/KR%20pathogen%20monitoring%20summary%2005-26-05.doc). Ceratomyxosis has been shown to persist in juvenile salmon after they enter salt water, and Foott et al. (2004) concluded that most smolts with detectable infection are likely to die from the disease.

Scheiff et al. (2001) noted that juvenile fish kills observed in 1997 and 2000 during screw-trap sampling occurred during periods of sustained high water temperatures, and past studies have indicated that resistance to ceratomyxosis may be reduced at higher water temperatures. Foott et al. (2004), however, found that the rate of mortality was not markedly different between Chinook salmon smolts held at 16°C and at 20°C in a hatchery setting after exposure, and concluded that the magnitude of parasite exposure may have a stronger influence on disease severity than rearing temperature.

Although infection with *C. shasta* does not appear to occur in the Trinity River, there is evidence that Chinook salmon smolts from the Trinity River become infected and diseased with ceratomyxosis after they enter the Klamath during their outmigration. In the summer of 2002, 19 percent of marked Trinity River hatchery Chinook salmon smolts collected in the estuary were found to be infected with *C. shasta* (Nichols et al., 2003). Klamath River steelhead are relatively resistant to ceratomyxosis. There is limited information on the susceptibility of coho salmon to ceratomyxosis. Bartholomew and Courter (2007) report that based on limited comparisons conducted in 2005, coho salmon are somewhat less resistant to ceratomyxosis than native trout and fall Chinook salmon. In that study, 39 percent of the coho salmon became infected, and mortality was 26 percent compared with 11 percent infection and 2 percent mortality in Chinook salmon at 90 days post-exposure, when fish were held at 13°C. They also report that in a similar study conducted by FWS in 2006, mortality in coho salmon was 2 percent, 19 days after exposure when fish were held at 18°C, but the prevalence of infection and percent of fish having clinical lesions was higher than it was for fall Chinook salmon and steelhead.

Oregon State University (2004) studied the prevalence of *C. shasta* within the project area extending from Keno reservoir downstream to the confluence with Beaver Creek, a tributary that enters the Klamath River near RM 161, 29 miles downstream of Iron Gate dam. Sentinel studies conducted by holding rainbow trout in live cages for 3 to 5 days at seven sites documented infection at all sites except for Keno reservoir (infections were observed in the Keno reach; in J.C. Boyle reservoir, bypassed reach, and peaking reach; in the Copco No. 2 bypassed reach; and in the Klamath River upstream of Beaver Creek). Mortality rates caused by *C. shasta* during a 70-day post-exposure holding period were less than

22 percent for most groups, with the exceptions of a 59 percent mortality rate observed for fish that were exposed during July in the J.C. Boyle bypassed reach and mortality rates of 75 and 90 percent for fish that were exposed in June and July, respectively, in the Klamath River upstream of Beaver Creek. Separate trials were conducted in April, June, July, September, and November at most sites.

Additional sampling was conducted using a recently developed assay technique called the Quantitative Polymerase Chain Reaction assay, which can measure *C. shasta* concentrations in water. Results from sampling at 19 locations generally mirrored the results of the sentinel studies. *C. shasta* was detected at all sites except Keno reservoir, and the highest concentration was found in the mainstem Klamath River upstream of Beaver Creek (Oregon State University, 2004). Assay sampling included several locations where sentinel studies had not been conducted, including one in the Williamson River (upstream of Upper Klamath Lake), which had the second-highest concentration of *C. shasta* of all of the sites that were sampled.

Oregon State University (2004) also conducted sampling to evaluate the abundance of *Manayunkia speciosa*, the polychaete that has been identified as an alternate host for both *C. shasta* and *P. minibicornis* (Bartholomew and Cone, 2006). Polychaetes were found to be most abundant in the river and in riverine sections of reservoirs. Stocking (2006) reported that polychaetes were especially abundant in fine benthic organic matter that is deposited in low velocity areas, primarily at the head of the project reservoirs and where the Williamson River enters Upper Klamath Lake. Within riverine areas, the microhabitat associated with the highest concentration of the polychaete was in *Cladophora spp*., a type of algae that forms mats by adhering strongly to any hard substrate, including cobbles and boulders in riverine areas. Stocking and Bartholomew (2007) observed that mats of *Cladophora spp*. contained large quantities of fine benthic organic material and diatoms, which provide a food source for the polychaetes. This macro-algae has a competitive advantage in nutrient enriched waters, and can become the dominant species, frequently covering the entire stream bed and displacing other macrophytes where it occurs (Stocking and Bartholomew, 2007).

Stocking (2006) found that infection rates of *M. speciosa* were highest in the Klamath River within 50 miles downstream of Iron Gate dam (figure 3-72), and he concluded that a likely explanation for this finding was that adult salmon carrying *C. shasta* spores spawn, die, and release these spores into the environment downstream of Iron Gate dam, where they infect *M. speciosa*. He also concluded that actinospores from these highly infected populations of *M. speciosa* can remain viable during the 5 days required for water to pass from Iron Gate dam to the Klamath estuary, as suggested by high mortality rates of susceptible rainbow trout exposed during sentinel studies throughout the lower Klamath River (figure 3-73).

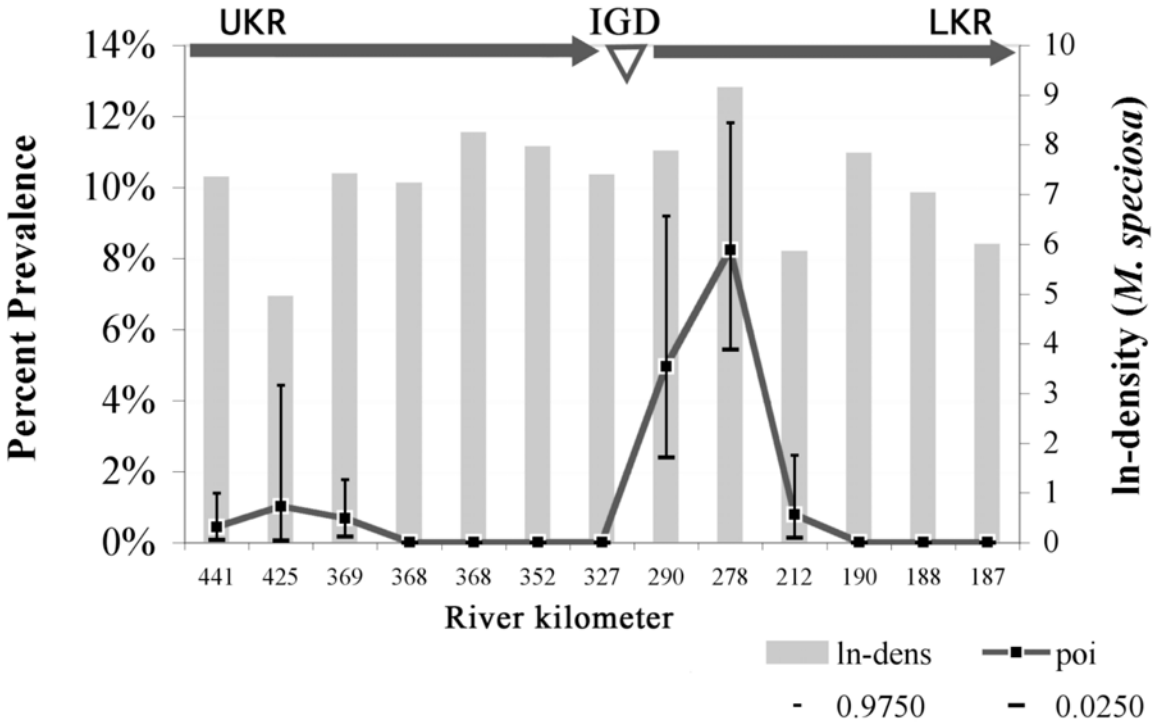


Figure 3-72. Estimates of Ceratomyxa shasta infection prevalence (poi) and associated confidence levels within selected populations of Manayunkia speciosa collected from the Klamath River. Sites sorted on the x-axis from Upper Klamath Lake (Rkm 441) going downriver towards the mouth. Abbreviations UKR = Upper Klamath River, IGD = Iron Gate dam, and LKR = Lower Klamath River. (Source: Stocking, 2006)

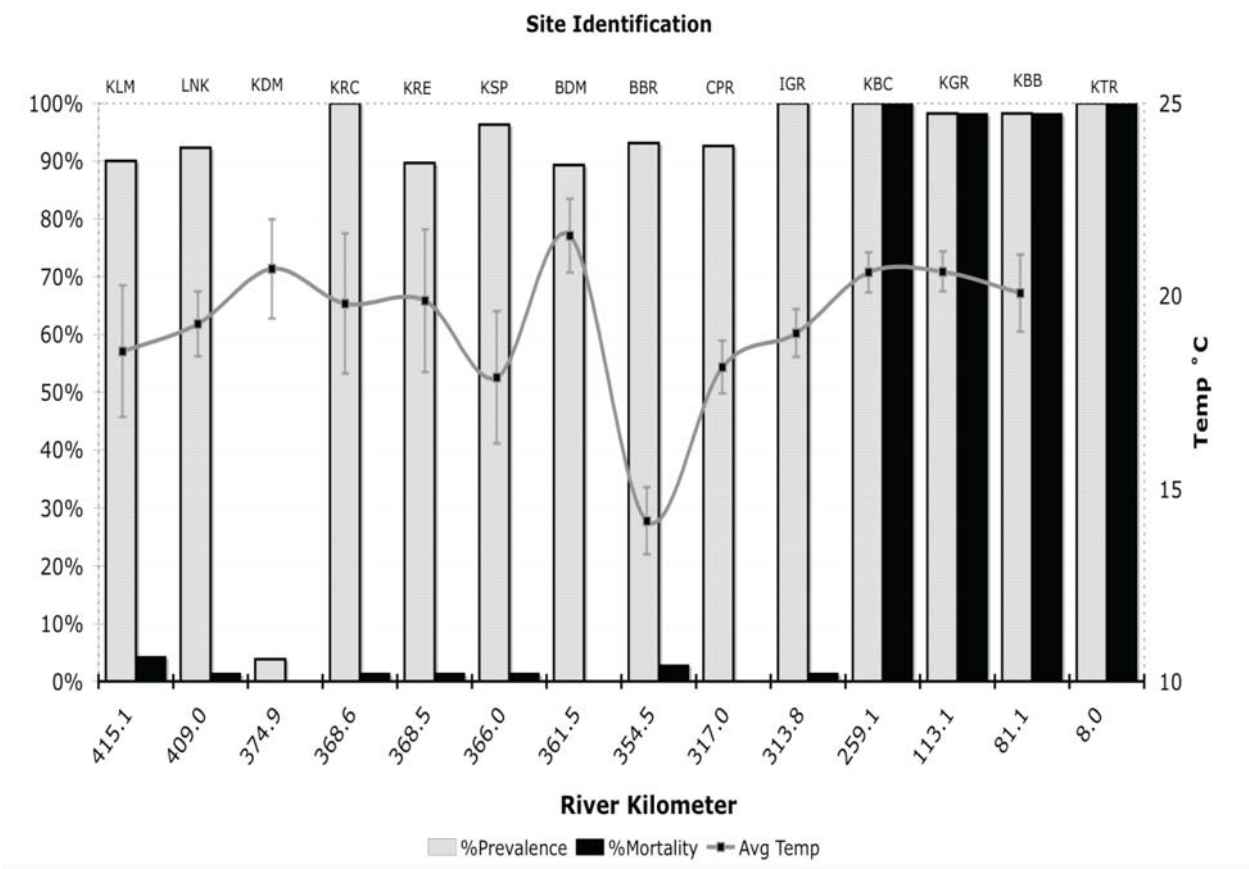


Figure 3-73. Percent prevalence and percent mortality of rainbow trout (Oncorhynchus mykiss) exposed in Klamath River (June 2004) locations reading from the uppermost site (left) to the lowest (right). (Source: Stocking, 2006)

Adult Salmonids

During the last half of September 2002, a major fish kill occurred in the lower 36 miles of the Klamath River. The primary cause of the fish kill was a disease outbreak from the common pathogens *Ichthyopthirius multifilis* (Ich) and *Flavobacterium columnare* (columnaris) (Guillen, 2003; Cal Fish & Game, 2004a; NAS, 2004). The fish kill was unprecedented in that it was the first major adult mortality event ever recorded in the Klamath River (Cal Fish & Game, 2004a).

Based on surveys conducted by FWS during the 2002 fish kill, Guillen (2003) estimated that a total of 33,527 adult anadromous salmonids were killed, including 32,533 fall Chinook salmon, 629 steelhead, 344 coho salmon, and one coastal cutthroat trout. Approximately 21.7 percent of the fall Chinook salmon, 38.7 percent of the steelhead, and 91.5 percent of the coho salmon were determined to be of hatchery origin. Guillen (2003) considered these estimates to be conservative, and Cal Fish & Game (2004a) suggest that the actual losses might have been twice as high as those reported above.

Based on an analysis of fish run timing, river flows, and water quality conditions that occurred in 2002, FWS concluded that a combination of factors resulted in conditions that lead to the fish kill (Guillen, 2003). These included an early peak in the return of a large run of fall Chinook salmon and low river discharges that apparently did not provide suitable attraction flows for migrating adult salmon, resulting in large numbers of fish congregating in the warm waters of the lower river. Guillen (2003) concluded that the high density of fish, low discharges, warm water temperatures, and possible extended

residence time of salmon created optimal conditions for parasite proliferation and precipitated an epizootic of Ich and columnaris.

Cal Fish & Game (2004a) also concluded that a combination of factors contributed to create conditions in 2002 that were stressful to salmonids and were conducive to a disease outbreak. Factors identified by Cal Fish & Game included atypically low flows and low river volume coupled with an above average run of fall Chinook salmon, which peaked 1 week earlier than average, and seasonably warm water temperatures that normally occur in September in the lower Klamath River. Cal Fish & Game (2004a) also reported that low flows and changes in the river channel caused by high flow events in the late 1990s may have impeded fish passage due to shallow water at several riffles under the prevailing low flows, and this combined with an above average run, contributed to high fish densities. The lack of a sand spit constriction at the river mouth combined with low flows also resulted in a lower than normal water volume within the estuary, which contributed to higher than normal fish densities.

3.3.3.1.5 Salmon and Steelhead Harvest and Harvest Management

The Klamath Fishery Management Council (KFMC) formed in 1985, is a federal advisory committee made up of commercial and recreational fishermen, Yurok and Hoopa Valley tribal fisheries representatives, and state and federal agencies (Cal Fish & Game, Oregon Fish & Wildlife, NMFS, and Interior). The KFMC meets each spring to review the past year's salmon harvest and predictions of salmon ocean abundance and harvests in the upcoming year that are developed by its technical advisory team. The KFMC then makes specific recommendations to the agencies that regulate the harvest of Klamath River Basin anadromous fish. Oregon Fish & Wildlife and Cal Fish & Game manage harvest of resident fish in their respective portions of the river.

The Pacific Fisheries Management Council (PFMC) regulates ocean harvest in the area from 3 to 200 miles offshore by considering the KFMC recommendations and developing regulations to be established by the Department of Commerce for offshore fisheries, and the California Fish and Game Commission for nearshore and Klamath River harvests. The guiding document for PFMC's management of commercial and recreational fisheries is the Pacific Coast Salmon Fishery Management Plan (Salmon FMP) (PFMC, 2003a). The Salmon FMP covers Chinook and coho salmon and, in odd years, pink salmon. PFMC does not regulate ocean harvests for steelhead or cutthroat trout, or for runs of even-year pink salmon, as these species are rarely caught in ocean fisheries.

The Salmon FMP was developed to comply with the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265, as amended through October 11, 1996), which states that "conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery." Optimum yield for a stock includes total salmon catch and mortality from fisheries within the exclusive economic zone[70] adjacent to Washington, Oregon, and California, and in waters of those states (including internal waters), and Idaho. PFMC must ensure that fishing regulations also meet or exceed the requirements of the ESA, and must manage fisheries to be consistent with NMFS conservation standards or recovery plans. To achieve optimum yield, PFMC developed fixed conservation objectives for Chinook and coho salmon stocks that are based either on achieving a specified number of adult spawners (spawner escapement) or a specified number of adult returns to a specific location (such as a dam or river) that would result in a target level of spawning adults.

The Yurok and Hoopa Valley tribes have a federally protected right to the fishery resource of their reservations sufficient to support a moderate standard of living or 50 percent of the total available harvest of Klamath-Trinity basin salmon, whichever is less. The in-river recreational harvest is set annually as a percentage of the non-tribal harvest allocation. The 50 percent tribal fisheries allocation for Klamath River Basin stocks is split further, with 80 percent going to the Yurok Tribe, and 20 percent to

[70]The exclusive economic zone is the area from 3 to 200 miles off the coast of the United States.

the Hoopa Valley Tribe. The Karuk Tribe fishing is limited to a spot at Ishi-Pishi Falls and is not limited to a specific allocation. Individual tribal members are assigned shares of the tribal allocation under the regulatory authority of the tribes.

Klamath River Fall Chinook Salmon

Klamath River fall Chinook salmon stocks are a major contributor to the ocean fisheries from central Oregon to central California. The Salmon FMP conservation objective states that 33 to 34 percent of the natural run of fall Chinook salmon must be allowed to escape all tribal, commercial, and recreational fisheries to spawn. In addition, there is a floor conservation requirement of no less than 35,000 natural spawners returning to Klamath River in any one year. If it is estimated that natural spawning escapement will exceed 35,000 fish, then harvest of fish in excess of 35,000 is allowed. If it is predicted that the conservation objective of 35,000 natural spawner escapement will not be met, a Conservation Alert is triggered, in which PFMC must recommend closure of all salmon fisheries within their jurisdiction that influence the stock, regardless of the status of other salmon stocks in the area. This includes the entire area from Pigeon Point in California to Florence, Oregon (PFMC, 2003) (figure 3-74).

The 2006 forecast for age-3 abundance was the lowest on record, and the spawning escapement floor of 35,000 naturally spawning Klamath River fall Chinook salmon was projected to not be attained even with complete closure of ocean salmon fisheries between Cape Falcon, Oregon and Big Sur, California. Therefore, PFMC's management measures required implementation of "emergency rule" to allow harvest. This resulted in complete closure of 2006 commercial ocean troll fisheries between Florence South Jetty to Horse Mountain (the Klamath Management Zone), and only a 15-day opening for Horse Mountain to Pt. Arena (PFMC, 2006a). Table 3-54 presents the harvest quotas established by PFMC for Klamath River fall Chinook salmon for 2001 through 2007. Figure 3-75 presents historical fall Chinook salmon landings by PFMC management zone, and table 3-55 presents harvest of age 3 and 4 Klamath River fall Chinook salmon in the Klamath Management Zone from 1986 through 2006.

Table 3-48 presents historical spawning escapement and in-river harvest of fall Chinook salmon in the Klamath River Basin. Figure 3-76 shows historical in-river returns along with natural spawning escapement, and total escapement (natural plus hatchery) from 1978 through 2006.

The 2006 preliminary postseason river run size estimate for KRFC was 61,630 adults compared to the preseason predicted river run size of 47,600 adults. The escapement to natural spawning areas was 30,422 adults, which was more than the preseason prediction of 21,100 adults. This was the third consecutive year of failing to meet the minimum spawner floor conservation objective for the stock (PFMC, 2007a).

The Klamath River Technical Advisory Team has predicted stronger returns for Klamath River fall Chinook salmon for 2007, and NOAA Fisheries approval of the Council-adopted fishing regime will result in an estimated 21,000 natural adult salmon spawners in the Klamath River after the allowed commercial and recreational harvests. The regulations for 2007 will allow about 40 percent of the usual commercial salmon harvest.

In June 2006, PFMC began analysis of Amendment 15 to the Salmon FMP, which would provide *de minimis* (minimum allowable) fishing opportunities during periods when a Conservation Alert for Klamath River fall Chinook salmon requires fishery closures, and to provide opportunities to harvest more robust salmon stocks that occur in the management area. In a draft environmental assessment (draft EA) issued in November 2006 for the Salmon FMP amendment, the PFMC identified a preferred alternative that would allow up to a 10 percent ocean fisheries impact rate on age-4 Klamath River fall Chinook salmon that results in natural spawning escapement of between 22,000 and 35,000, including river recreational and tribal fisheries. If natural spawner escapement is projected to be less than 22,000 fish, the PFMC would reduce the 10 percent age-4 ocean impact rate to reflect the status of the stock. The draft EA was submitted to NMFS for approval, with anticipated implementation date of May 1, 2007.

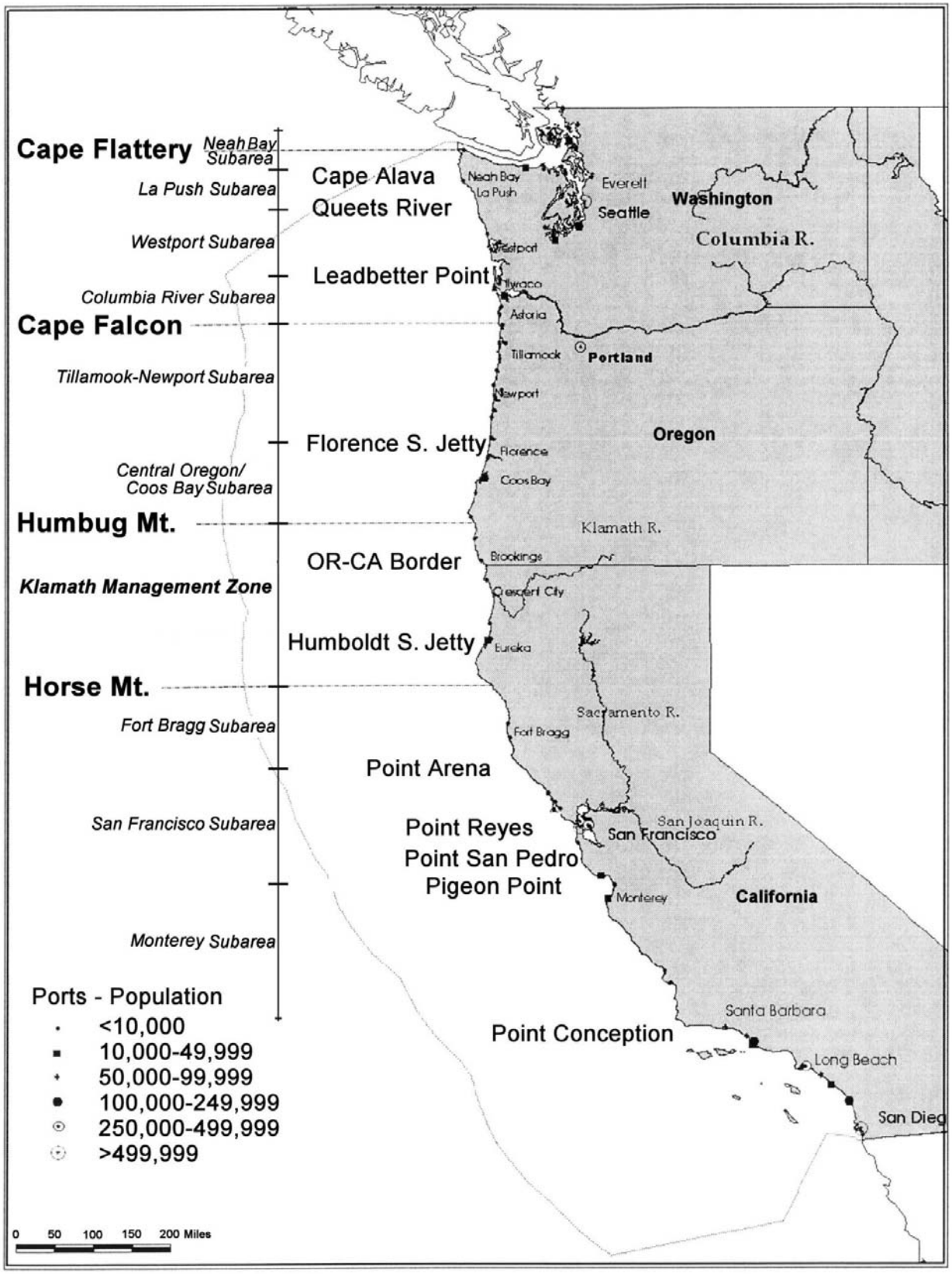


Figure 3-74. Pacific coast ports and management zones. (Source: PFMC, 2005a)

Table 3-54. PFMC stock management quotas for 2001-2005 for Klamath River fall Chinook salmon. (Sources: PFMC, 2001, 2002a, 2003b, 2004b, 2005c, 2006b, 2007c)

	Allocation [a]	Quota
Klamath River Escapement	2001: 47,000 target natural spawning escapement [b]	
	2002-2005: Minimum 35,000 natural spawning escapement goal	
	2006: 21,100 target natural spawning escapement goal	
Federally recognized tribal harvest (to Yurok and Hoopa Valley tribal fisheries)/Non-tribal harvest	50%/50%	2001: 75,500 adult fish each
		2002: 50,400 adult fish each
		2003: 41,400 adult fish each
		2004: 31,000 adult fish each
		2005: 8,300 adult fish each
		2006: 10,000 adult fish each
		2007: 40,800 adult fish each
Non-tribal harvest:		
KMZ[c] ocean fishery	2001: 60.5%	2001: 45,600 adult fish
	2002: 59.5%	2002: 30,000 adult fish
	2003: 73.9%	2003: 30,600 adult fish
	2004: 85 %	2004: 26,500 adult fish
	2005: 85 %	2005: 7,100 adult fish
	2006: 100%	2006: 8,400 adult fish[d]
	2007: 16.2%	2007: 12,000 adult fish
KMZ[b] ocean recreational fishery (percent of KMZ ocean fishery allocation in row above)	2001: 17.0%	2001: 7,700 adult fish
	2002: 11%	2002: 3,300 adult fish
	2003: 14.8%	2003: 4,500 adult fish
	2004: 14.1%	2004: 3,700 adult fish
	2005: 17.1%	2005: 1,200 adult fish
	2006: 8.8%	2006: 900 adult fish
	2007: 16.2%	2007: 1,920 adult fish
Klamath River recreational fishery	2001: 39.5%	2001:. 29,800 adult fish
	2002: 40.7%	2002: 20,500 adult fish
	2003: 26.1%	2003: 10,800 adult fish
	2004: 15%	2004: 4,700 adult fish
	2005: 15%	2005: 1,200 adult fish
	2006: 0%	2006: 300 adult fish[e]
	2007: 16%	2007: 10,600 adult fish

Notes: KMZ – Klamath Management Zone

[a] Percentages rounded.

[b] Escapement is the number of naturally spawning salmon escaping ocean fisheries and entering freshwater.

[c] The area between Humbug Mountain, Oregon, and Horse Mountain, California.

[d] Allocation for KMZ fish harvested outside the KMZ area.

[e] Closed to recreational fishing; allocation is for incidental mortality from catch and release fisheries.

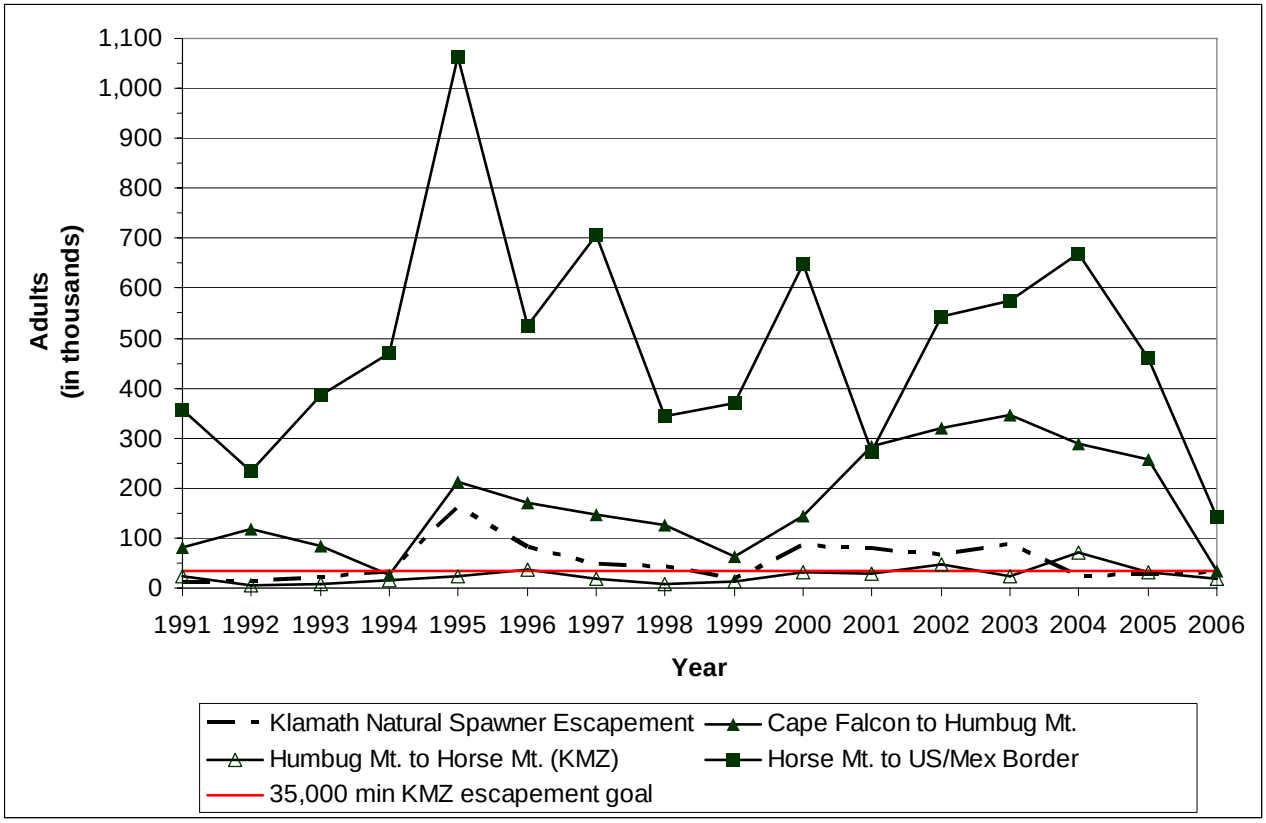


Figure 3-75. Klamath River total fall Chinook salmon adult natural spawning escapement and ocean landings by PFMC management zone. (Source: PFMC, 2007a)

Table 3-55. Harvest (# fish) of age-3 and age-4 Klamath River fall Chinook salmon. (Source: PFMC, 2007b)

	Ocean Fisheries (Sept. 1 -Aug. 31)							River Fisheries		
	KMZ									
Year	Troll	Sport	Subtotal	North of KMZ	South of KMZ	Subtotal	Ocean Total	Net	Sport	Total
1986	43,515	6,001	49,516	97,525	155,205	252,730	302,246	25,100	21,000	46,100
1987	39,308	9,590	48,898	114,677	106,255	220,932	269,830	52,400	19,900	72,300
1988	27,607	8,693	36,300	50,818	157,098	207,916	244,216	51,100	21,800	72,900
1989	12,232	21,378	33,610	47,187	39,718	86,905	120,515	43,700	8,600	52,300
1990	4,036	7,305	11,341	76,431	21,657	98,088	109,429	7,300	3,600	10,900
1991	0	2,038	2,038	1,879	4,996	6,875	8,913	9,716	3,293	13,009
1992	172	55	227	2,770	12	2,782	3,009	5,330	974	6,304
1993	0	812	812	1,669	7,965	9,634	10,446	9,212	3,160	12,372
1994	41	1,645	1,686	1,117	4,685	5,802	7,488	11,209	1,783	12,992
1995	0	1,209	1,209	13,614	16,180	29,794	31,003	14,797	6,017	20,814
1996	769	3,451	4,220	10,277	29,906	40,183	44,403	56,322	12,741	69,063
1997	3	403	406	1,071	4,185	5,256	5,662	10,900	5,322	16,222
1998	0	107	107	4,269	466	4,735	4,842	9,395	7,603	16,998
1999	76	552	628	2,907	1,128	4,035	4,,663	13,770	2,242	16,012
2000	520	4,137	4,657	11,188	25,946	37,134	41791	29,191	5,649	34,840
2001	1,418	1,698	3,116	8,551	9,932	18,483	21,599	38,644	12,113	50,757
2002	2,198	1,767	3,965	5,219	21,217	26,436	30,401	23,663	10,321	33,984
2003	1,375	2,510	3,885	14,062	85,655	99,717	103,602	29,750	9,653	39,403
2004	3,935	3,970	7,905	38,917	61,210	100,127	108,032	22,103	3,761	25,864
2005	248	952	1,200	6,342	4,769	11,111	12,311	7,442	1,945	9,387
2006	271	1,241	1,512	5,475	1,258	6,733	8,245	9,960	55	10,015

Notes: KMZ – Klamath Management Zone

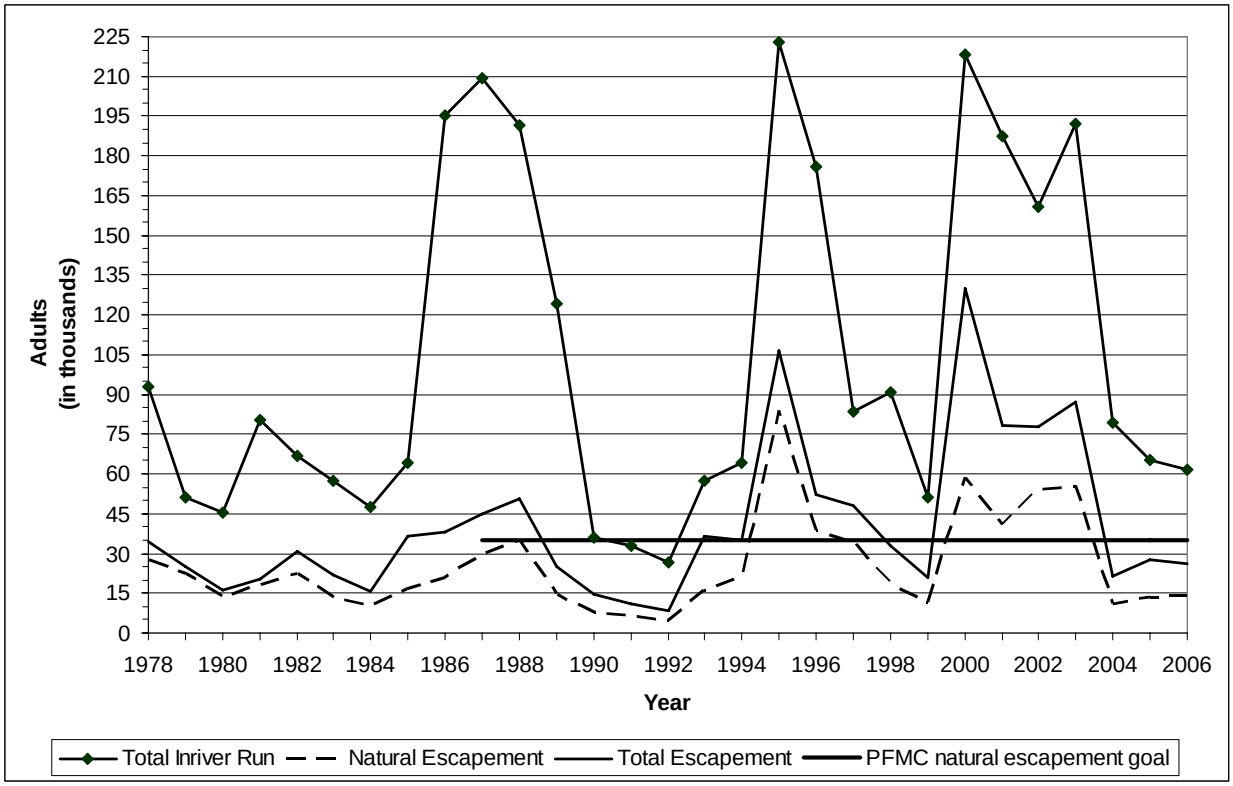


Figure 3-76. Klamath River adult fall Chinook salmon river return and spawning escapements, 1978 to 2006. (Source: PFMC, 2007a)

Table 3-56. Estimates of Yurok and Hoopa Valley Reservation gillnet harvest, 1990-2006.[a] (Sources: PFMC, 2007a, 2002a)

		Chinook Salmon (numbers of fish)					
		Spring Run			Fall Run		
Year	**Area**	**Jack**	**Adult**	**Total**	**Jack**	**Adult**	**Total**
1990	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	386	386	13	3,536	3,549
	Middle Klamath	0	521	521	36	1,116	1,152
	Upper Klamath	0	504	504	102	2,331	2,433
	Trinity	24	865	889	36	811	847
	Total	24	2,276	2,302	187	7,794	7,981
1991	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	70	70	7	3,902	3,909
	Middle Klamath	0	46	46	9	1,765	1,774
	Upper Klamath	3	167	170	16	3,251	3,267
	Trinity	0	263	263	30	1,310	1,342
	Total	3	546	549	62	10,228	10,290
1992	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	15	15	124	1,152	1,275
	Middle Klamath	0	97	97	62	1,107	1,159
	Upper Klamath	0	284	284	148	2,580	2,726
	Trinity	0	346	346	42	946	988
	Total	0	742	742	366	5,785	6,151

		Chinook Salmon (numbers of fish)					
		Spring Run			Fall Run		
Year	**Area**	**Jack**	**Adult**	**Total**	**Jack**	**Adult**	**Total**
1993	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	19	19	62	3,017	3,079
	Middle Klamath	0	320	320	33	1,632	1,865
	Upper Klamath	0	211	211	47	3,495	3,542
	Trinity	0	228	226	33	1,492	1,525
	Total	0	778	778	175	9,636	9,811
1994	Commercial Estuary		-	-	-	-	-
	Subsistence Estuary	9	152	161	80	4,341	4,421
	Middle Klamath	14	110	124	4	1,448	1,452
	Upper Klamath	3	239	242	71	3,658	3,729
	Trinity	0	255	255	94	2,266	2,360
	Total	26	756	782	249	11,713	11,962
1995	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	656	656	117	5,200	5,317
	Middle Klamath	0	1,312	1,312	44	2,415	2,459
	Upper Klamath	0	824	624	47	4,610	4,657
	Trinity	93	1,175	1,268	268	3,383	3,651
	Total	93	3,767	3,860	476	15,608	16,084
1996	Commercial Estuary	16	3,113	3,129	127	40,020	40,147
	Subsistence Estuary	1	1,851	1,852	36	9,093	9,129
	Middle Klamath	9	673	682	7	1,570	1,577
	Upper Klamath	3	268	271	12	3,023	3,035
	Trinity	6	1,162	1,186	8	2,770	2,776
	Total	35	7,086	7,122	190	56,476	56,668
1997	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	0	2,919	2,919	21	5,574	5,596
	Middle Klamath	0	1,102	1,102	3	1,479	1,482
	Upper Klamath	0	1,416	1,419	5	3,796	3,801
	Trinity	1	1,250	1,251	6	1,238	1,244
	Total	1	8,690	6,691	35	12,087	12,122
1998	Commercial Estuary	-	-	-	-	-	-
	Subsistence Estuary	2	621	623	16	3,454	3,470
	Middle Klamath	0	937	937	9	1,324	1,333
	Upper Klamath	0	780	780	23	3,874	3,897
	Trinity	45	426	471	5	1,535	1,540
	Total	47	2,764	2,811	53	10,187	10,240
1999	Commercial Estuary	-	-	-	-	2,077	2,077
	Subsistence Estuary	2	456	456	127	2,315	2,442
	Middle	0	1,343	1,343	49	2,261	2,310
	Upper Klamath	0	593	593	237	4,784	5,021
	Trinity	13	776	769	96	2,978	3,074
	Total	15	3,188	3,183	509	14,415	14,924
2000	Commercial Estuary	-	33	33	-	4,104	4,104
	Middle Klamath	-	2	2	-	186	186
	Upper Klamath	-	1	1	-	813	813
	Subsistence Estuary	5	1,739	1,744	35	13,209	13,209
	Middle Klamath	0	509	509	29	1,049	1,078
	Upper Klamath	8	909	917	111	4,127	4,238
	Trinity	29	1,325	1,354	128	5,926	6,090
	Total	42	4,518	4,560	303	29,415	29,718

		Chinook Salmon (numbers of fish)					
		Spring Run			Fall Run		
Year	**Area**	**Jack**	**Adult**	**Total**	**Jack**	**Adult**	**Total**
2001	Commercial Estuary	79	4,637	4,716	63	7,011	7,074
	Upper Klamath	1	58	59	1	51	52
	Subsistence Estuary	152	8,846	8,998	198	21,956	22,154
	Middle Klamath	0	134	134	28	1,697	1,725
	Upper Klamath	19	1,504	1,523	49	2,976	3,025
	Trinity	46	4,164	4,210	60	4,954	5,014
	Total	297	19,343	19,640	399	38,645	39,044
2002	Commercial Estuary	7	1,852	1,859	7	8,952	8,959
	Upper Klamath	-	-	-	-	-	
	Subsistence Estuary	25	6,551	6,576	10	11,197	11,207
	Middle Klamath	70	1,310	1,380	10	729	739
	Upper Klamath	24	2,205	5,229	31	2,528	2,559
	Trinity	40	3,052	3,062	68	1,168	1,236
	Total	166	14,970	15,136	126	24,574	24,700
2003	Commercial Estuary	4	779	783	12	17,083	17,095
	Upper Klamath	0	0	0	0	0	0
	Subsistence Estuary	10	1,800	1,810	4	5,604	5,608
	Middle Klamath	0	2,355	2,355	5	1,376	1,381
	Upper Klamath	0	1,730	1,730	11	3,200	3,211
	Trinity	7	2,380	2,387	12	2,771	2,783
	Total	21	9,044	9,065	44	30,034	30,078
2004	Commercial Estuary	2	408	410	13	14,251	14,264
	Upper Klamath	0	0	0	13	540	554
	Subsistence Estuary	10	2,178	2,188	62	6,787	6,848
	Middle Klamath	6	2,346	2,352	14	577	591
	Upper Klamath	11	1,715	1,726	46	1,959	2,005
	Trinity	62	1,944	2,006	20	1,689	1,709
	Total	91	8,591	8,682	168	25,083	25,971
2005	Commercial Estuary	0	0	0	0	0	0
	Upper Klamath	0	3,113	3,129	0	0	0
	Subsistence Estuary	0	430	430	21	2,233	2,254
	Middle Klamath	0	520	520	5	462	467
	Upper Klamath	0	1,232	1,232	33	2,851	2,884
	Trinity	16	1,858	1,858	11	2,409	2,420
	Total	33[b]	7,153	7,169	70	7,955	8,025
2006[c]	Commercial Estuary	0	0	0	0	0	0
	Upper Klamath	0	0	0	0	0	0
	Subsistence Estuary	0	309	309	30	2,726	2,756
	Middle Klamath	3	1,113	1,116	92	1,310	1,402
	Upper Klamath	11	1,281	1,292	148	,2,086	2,234
	Trinity	56	1,632	1,688	145	4,163	4,308
	Total	70	4,335	4,405	415	10,285	10,700

[a] FWS generated estimates for Klamath River portion from 1983 to 1993. The Fisheries Department of the Hoopa Valley Business Council has monitored the Trinity River fishery since 1982. The Yurok Tribe Fisheries Program monitored the Klamath River portion in 1994 and 1995.

[b] Total reflects more than in rows above; however, this is what was reported by PMFC in the source document.

[c] Preliminary estimate.

- = Estimate not made.

After reviewing the data and in collaboration with NOAA Fisheries, the states, tribes, and fishermen, the PFMC determined that conditions in 2007 would allow for the plan to be temporarily be set at 21,000 fall Chinook salmon natural spawners, without compromising the long-term productivity of the stock.

During 2005, 394,007 natural and hatchery fall Chinook salmon adults were estimated to have returned to the Sacramento River Basin for spawning, and preliminary estimates for 2006 were 270,224 fish, exceeding PFMC's conservation escapement objective of 122,000 to 180,000 adults (figure 3-77). The 2007 adult escapement forecast for adult Central Valley Chinook salmon is 331,200 fish.

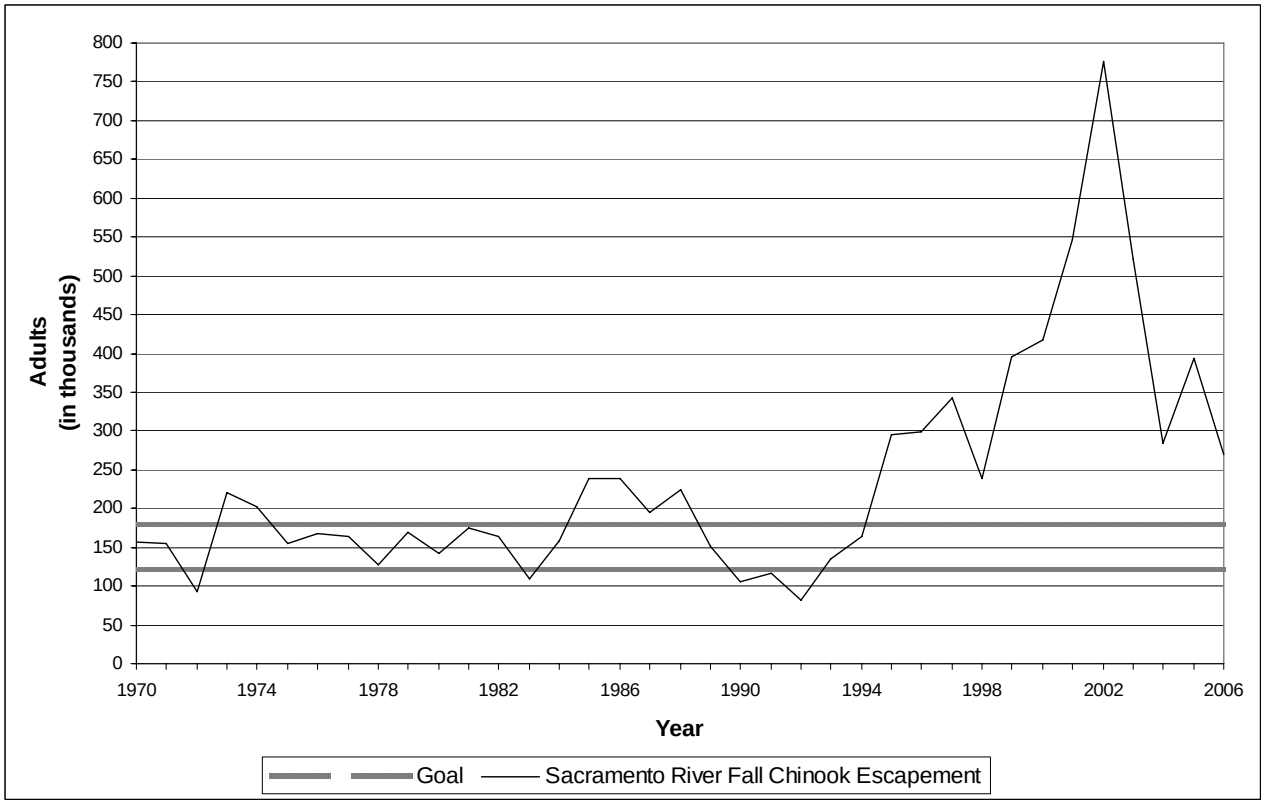


Figure 3-77. Natural and hatchery Sacramento River fall Chinook salmon escapement to mouth of Sacramento River. (Source: PFMC, 2007a)

The California Fish and Game Commission annually establishes regulations to manage the Klamath River sport harvest portion of the PFMC quota. To allow fishing opportunities throughout the Klamath River Basin, the quota allowance is typically evenly split, with 50 percent of the quota allocated to the Klamath River below the Highway 96 bridge at Weitchpec and 50 percent to the remainder of the Klamath River Basin above the Highway 96 bridge, including the Trinity River. In 2006, the California Fish and Game Commission ruled[71] that the fall Chinook salmon quota for the entire Klamath River Basin was zero. For 2007, the proposed regulations allow for up to 15,000 fall Chinook salmon to be harvested, with restrictions on size and area at various times.[72]

[71]California Fish and Game Commission regulations, accessed from http://www.fgc.ca.gov/2006/7_50b91_1pa.pdf on June 21, 2006.

[72]http://www.fgc.ca.gov/2007/7_50b91_1regs2.pdf.

From 1987 through 1989, the Yurok and Hoopa Valley Reservation gillnet fisheries in the estuary averaged 27,500 Chinook salmon annually, but from 1990 through 1998 there was no commercial harvest in the estuary except in 1996 (PFMC, 2005a). Table 3-56 presents the Yurok and Hoopa Valley Reservation tribal gillnet harvest of Chinook salmon for 1990 through 2006. From 1999 to 2002, the subsistence fishery has exceeded the commercial harvest, but this trend was reversed in 2003 and 2004, when the commercial harvest was more than double the subsistence fishery. In 2005 and 2006, there was no commercial tribal harvest. Table 3-57 presents estimates of angler harvest from 1983 through 1987.

Table 3-57. Klamath River angler harvest estimates for Chinook and coho salmon, and steelhead 1983 to 1987 seasons. (Source: Hopelain, 2001)

Harvest area	Angler trips	Angler hours	Chinook Salmon		Coho Salmon		Steelhead	
			grilse	adults	grilse	adult	halfpounders	adult
1983[a]								
Area 1[b]			60	750				
Area 2-3			175	1,125				
Total			**235**	**1,875**				
1984								
Area 1	2,2844	60614	175	548	57	0	260	88
Areas 2[c]	1,4938	49844	256	257	88	4	3165	1454
Area 3[d, e]	n/a	n/a	128	1,799				
Total	**37782**	**110498**	**559**	**2604**	**145**	**4**	**3425**	**1542**
1985								
Area 1	21,399	68,070	1,479	2,427	12	41	135	107
Area 2	18,761	70,171	2,331	438	35	4	3,626	3,184
Area 3	n/a	n/a	1,943	563				
Total	**40,160**	**138,241**	**5,753**	**3,428**	**47**	**45**	**3,761**	**3,291**
1986								
Area 1	28,274	89,092	704	2,456	0	4	124	85
Area 2	18,156	71,564	2,257	2,661	50	15	2,073	2,905
Area 3	n/a	n/a	3,009	3,871				
Total	**46,430**	**160,656**	**5,970**	**8,988**	**50**	**19**	**2,197**	**2,990**
1987								
Area 1	26,292	79,534	146	2,455	1	0	98	43
Area 2	24,972	99,047	2,980	5,648	80	152	2,160	1,753
Area 3	n/a	n/a	1,490	3,655				
Total	**51,264**	**178,581**	**4,616**	**11,758**	**81**	**152**	**2,258**	**1,796**

[a] Creel census not conducted in 1983. Estimates based on previous season's harvest levels.

[b] Area 1= estuary, mouth (RM 0) to Highway 101 Bridge (RM 3). Estimates based on creel data.

[c] Area 2 = Highway 101 Bridge (RM 3) to Johnson's (RM 24). Estimates based on creel data.

[d] Area 3 = Johnson's (RM 24) to Iron Gate dam (RM 191). Angler interviews were not conducted in this area.

[e] Harvest estimates for coho salmon and steelhead were not determined for Area 3.

Coho Salmon

The majority of coho salmon harvested in the Oregon Production Index area (Leadbetter Point, Washington, to the U.S./Mexico border) originate from stocks produced in rivers located within that same

area. These stocks include hatchery and natural production from the Columbia River, Oregon Coast, and northern California, including the Klamath River hatcheries.

The Salmon FMP allocates the allowable coho salmon harvest between recreational and commercial fisheries with a preference towards recreational fisheries. If stocks are projected to be below 150,000 fish, all of the allowable ocean harvest of coho salmon is allocated to recreational fishery. The overall abundance estimate for Oregon Production Index area stocks in 2006 was 557,100, down from 592,100 in 2005 and less than the 10-year average of 715,300 (figure 3-78). Spawner estimates are not available for ESA-listed California Coastal coho salmon stocks. Estimates are available for escapement to Klamath River Basin hatcheries, but not for coho salmon spawning in natural areas. In 2005, a total of 16,268 coho salmon returned to Trinity River Hatchery and 1,395 coho salmon returned to Iron Gate Hatchery. These values exceed the combined goal of 2,000 adults (PFMC, 2006b). Retention of coho salmon in all California fisheries is prohibited.

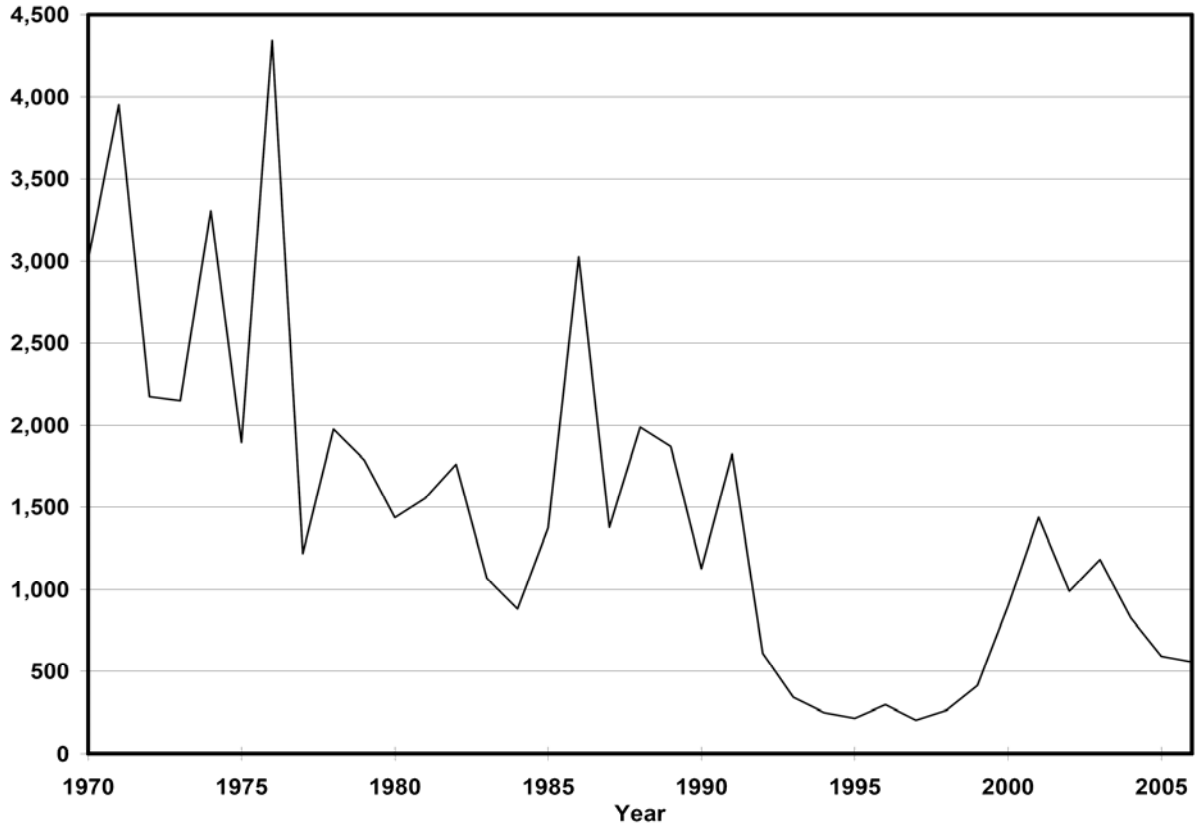


Figure 3-78. Oregon production index area coho salmon abundance estimates by stratified random survey accounting methods, 1970 to 2006. (Source: PFMC, 2007a)

Commercial troll fisheries have been closed to retention of coho salmon south of Cape Falcon since 1993, and recreational fisheries targeting coho salmon were closed from 1994 through 2003. In 2004 and 2005, limited recreational harvest of hatchery coho salmon was allowed from Cape Falcon to the California-Oregon border from June 18 until the earlier of July 31 or a landed quota of 40,000 marked fish. In 2006, the landed quota was 20,000 marked coho salmon. The area south of Humbug Mountain to Horse Mountain was closed to coho salmon beginning July 5 during 2004, 2005, and 2006. The retention prohibition for coho salmon south of Horse Mountain continues to be in place to protect Oregon coastal coho salmon stocks.

Harvest of coho salmon has been prohibited in the Klamath River since 1994, with the exception of sanctioned tribal harvest for subsistence, ceremonial, and commercial purposes by the Yurok, Hoopa Valley, and Karuk tribes. The Yurok Tribal Fisheries Program reported that annual harvest of coho salmon from reservation lands on the lower Klamath River averaged 244 fish (67 percent of which were marked hatchery fish) between 1997 and 2001, though this average was influenced by a harvest of almost 900 fish in 2001. In the other 4 years, harvest did not exceed 135 fish (Good et al., 2005).

Table 3-57 presents angler harvest estimates in the Klamath River for 1983 through 1987 (prior to the closure of the sport fishery for coho salmon in 1994) based on creel census and tag returns. The angler catch of adult coho salmon ranged from 4 to 152 fish, and the catch of coho salmon grilse ranged from 47 to 145 fish (Hopelain, 2001).

Steelhead

The California Fish and Game Commission regulates steelhead fishing in the Klamath River Basin. Current regulations state that all wild trout and steelhead must be released immediately. One brown trout, and either one hatchery trout or hatchery steelhead may be retained in prescribed portions of the basin.[73] Table 3-57 presents angler harvest estimates in the Klamath River for steelhead from 1983 through 1987. The estimated catch of adult steelhead ranged from 1,542 to 3,291 adults, and from 2,197 to 3,761 half-pounders (Hopelain, 2001).

3.3.3.1.6 Resident Fish Species

Rainbow Trout

Behnke (1992) considers the strains of rainbow trout that predominate inland of the Cascade range to be a separate subspecies from the coastal form. In the Klamath River Basin, he identifies the inland form as the Upper Klamath redband trout, *Oncorhynchus mykiss newberrii*, while he considers steelhead and resident rainbow trout downstream of Upper Klamath Lake to be primarily coastal rainbow trout, *Oncorhynchus mykiss irideus*. He indicates that there may be two distinct groups of redband trout in the upper basin, one that is adapted to lakes and another that is adapted to streams. Classification of resident rainbow trout populations in the lower part of the basin appears to be less distinct, as Behnke (1992) reports that trout in some of the small tributaries downstream of Upper Klamath Lake have characteristics that are typical of inland redband trout. Because some genetic mixing between the subspecies is likely to occur and the ancestry of specific populations cannot be determined without genetic testing, we refer to all resident *O. mykiss* in the basin as rainbow trout, and the anadromous form as steelhead.

Upper Klamath Lake supports a population of large rainbow trout, which appear to be adapted to harsh water quality conditions and resistant to the endemic protozoan *C. shasta*, which causes high rates of mortality in non-resistant strains of rainbow trout. This population supports a catch and release fishery for trophy-sized trout. Behnke (1992) reported seeing hundreds of 1 to 5 kilogram (2 to 11 pound) trout in clear-water sections of the lake that are influenced by spring inflows.

The free-flowing reach of the Klamath River downstream of Keno dam also supports a good rainbow trout fishery, although the fishing season in this reach is closed during the summer because high water temperatures cause excessive mortality in a catch-and-release fishery. Most of the trout in this reach spawn in Spencer Creek. In 1991, Oregon Fish & Wildlife collected 1,813 adult rainbow trout at a weir constructed across Spencer Creek, with peak upstream movement observed in April (Buchanan et al., 1991). During outmigrant trapping, a total of 4,218 fry and 25,618 juvenile rainbow trout were

[73]California Fish and Game Commission regulations, accessed from http://www.fgc.ca.gov/2006/7_50b91_1paregs.pdf on August 28, 2006.

collected. Peak downstream movement of fry occurred in August and September, while the peak movement of juveniles occurred in May (Buchanan et al., 1991).

The J.C. Boyle bypassed and peaking reaches also support good fisheries for rainbow trout. Most of the fish in these reaches spawn in Shovel Creek or in the bypassed reach. During two surveys conducted in the bypassed reach during 2003, PacifiCorp identified 66 trout redds. A single survey conducted in Shovel Creek in April 2003 revealed 43 redds between RM 0.6 and RM 0.9. In addition, 11 of 14 adult trout that were radio-tagged in the California segment of the peaking reach migrated into Shovel Creek during the spawning season, and 2 of the 14 adult trout radio-tagged in the Oregon segment moved downstream and entered Shovel Creek.

Resident Lampreys

In addition to the anadromous Pacific lamprey, there are at least three resident species of lampreys that are known to occur in the Klamath River Basin. Accurately determining the species composition and distribution of lampreys is complicated by a lack of distinguishing characteristics among ammocoetes, the life stage that is the most readily collected during field surveys. The parasitic Klamath River lamprey is believed to be widely distributed in the basin upstream of and downstream of Upper Klamath Lake (Moyle, 2002). Other species that are known to occur in the watershed upstream of Upper Klamath Lake are the parasitic Miller Lake lamprey, a landlocked form of the parasitic Pacific lamprey referred to as the "Klamath Lake lamprey," and the non-parasitic Pit-Klamath brook lamprey.

All lamprey species have a similar early life history. After hatching, ammocoetes drift downstream to areas of low velocity and silt or sand substrate, where they burrow into the stream bottom and live as filter feeders for 2 to 7 years (FWS, 2004a). After they transform into adults, the nonparasitic species do not feed, while the parasitic species feed on a variety of fish species. Anadromous species migrate into the ocean to feed, while resident species remain in fresh water for their entire life cycle.

The Klamath River lamprey is reported to occur in the Klamath River downstream of Iron Gate dam, in the Trinity River, in the Klamath River upstream of Iron Gate dam, in Spencer Creek, and in Upper Klamath Lake. In Upper Klamath Lake, ammocoetes are reported to metamorphose in the fall, spend 12 to 15 months in Upper Klamath Lake where they exhibit parasitic feeding habits, then spawn in the spring (Kostow, 2002). Adult Klamath River lamprey range in length from approximately 6 to 11 inches, much smaller than the typical size range of 12 to 30 inches given for adult Pacific lamprey by Moyle (2002).

3.3.3.1.7 Aquatic Macroinvertebrates

In fall 2002, PacifiCorp conducted general macroinvertebrate sampling at 101 transects within 21 riverine study reaches between Link River dam and the Shasta River and at 18 transects within 6 study reaches in Fall Creek. In addition, 5 transects were sampled in each of the four main project reservoirs (Keno, J.C. Boyle, Copco reservoir, and Iron Gate). Seventeen of the riverine sites were sampled again in spring 2003. In addition, surveys focused on locating large bivalve species were conducted in Keno reach, J.C. Boyle peaking reach, and Klamath River downstream of Iron Gate dam.

The results of the general macroinvertebrate surveys indicate that invertebrates are abundant throughout the project area, with typical densities ranging between 4,000 and 8,000 invertebrates per square meter. Maximum densities were observed in the Keno reach (figure 3-79), while the number of species of mayflies, stoneflies, and caddisflies (important prey taxa for fish species) generally increased in the downstream direction (figure 3-80). Dominant species in riverine reaches included caddisflies (*Hydropsyche* spp., *Hydroptila* spp., and *Amiocentrus aspilus*), blackfly (*Simulium* spp.), midges (*Rheotanytarsus* spp. and *Cricotopus* spp.), beetle (*Zaitzevia* spp.), and mayflies (*Baetis tricaudatus* and *Acentrella* spp.). The invertebrate community in reservoirs was dominated by species that are more

tolerant of impaired water quality conditions, especially in Keno reservoir, which showed a high abundance of invertebrates but low diversity, and the community was dominated by a few species.

PacifiCorp reported finding 11 species of bivalves during the general invertebrate sampling and the focused bivalve species sampling. Table 3-58 shows the sampling sites where each species was found. The only large bivalve species found were the Oregon floater and the western ridgemussel. The only species found that has a special management status was the montane peaclam, which is considered a federal species of concern and a Forest Service sensitive species. The montane peaclam is classified as an S1 (extremely endangered in known range) species in the California Natural Diversity Database and by the Oregon Natural Heritage Program.

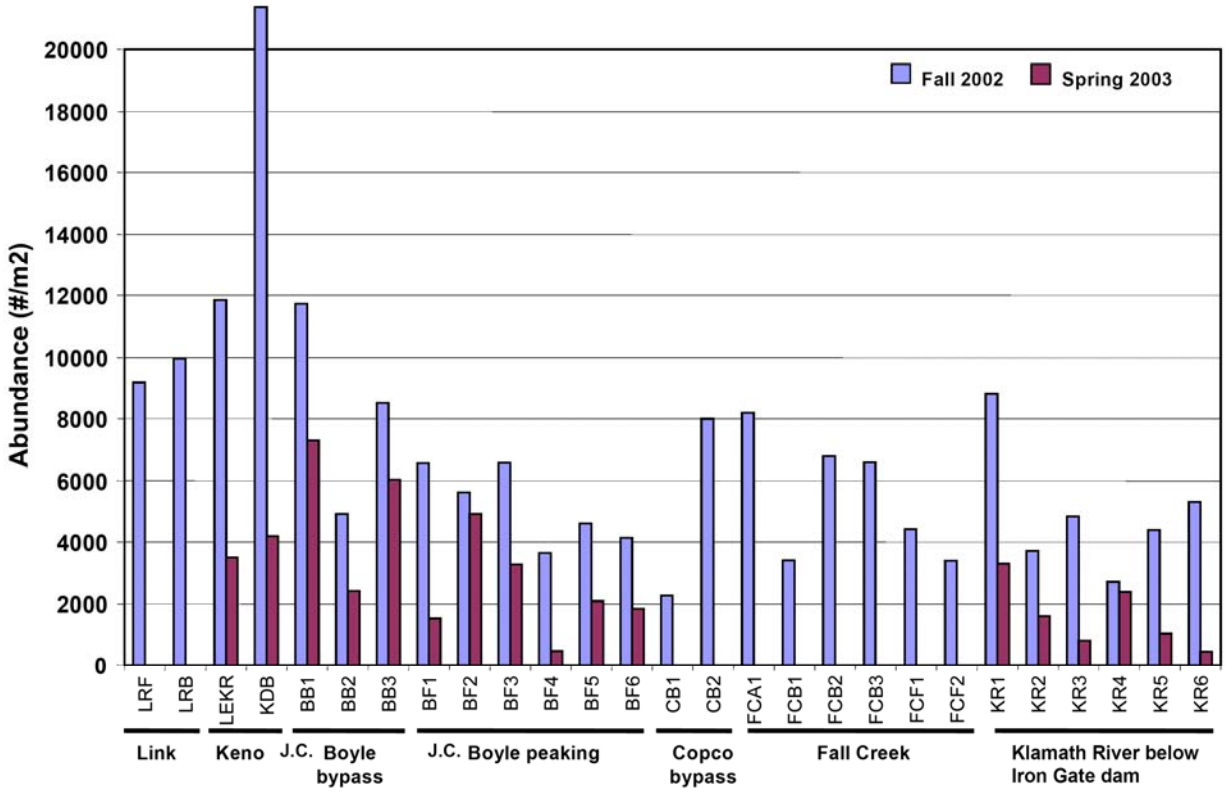


Figure 3-79. Total invertebrate density measured during fall 2002 and spring 2003 in the Klamath River between Link River and the confluence with the Shasta River. (Source: PacifiCorp, 2004f)

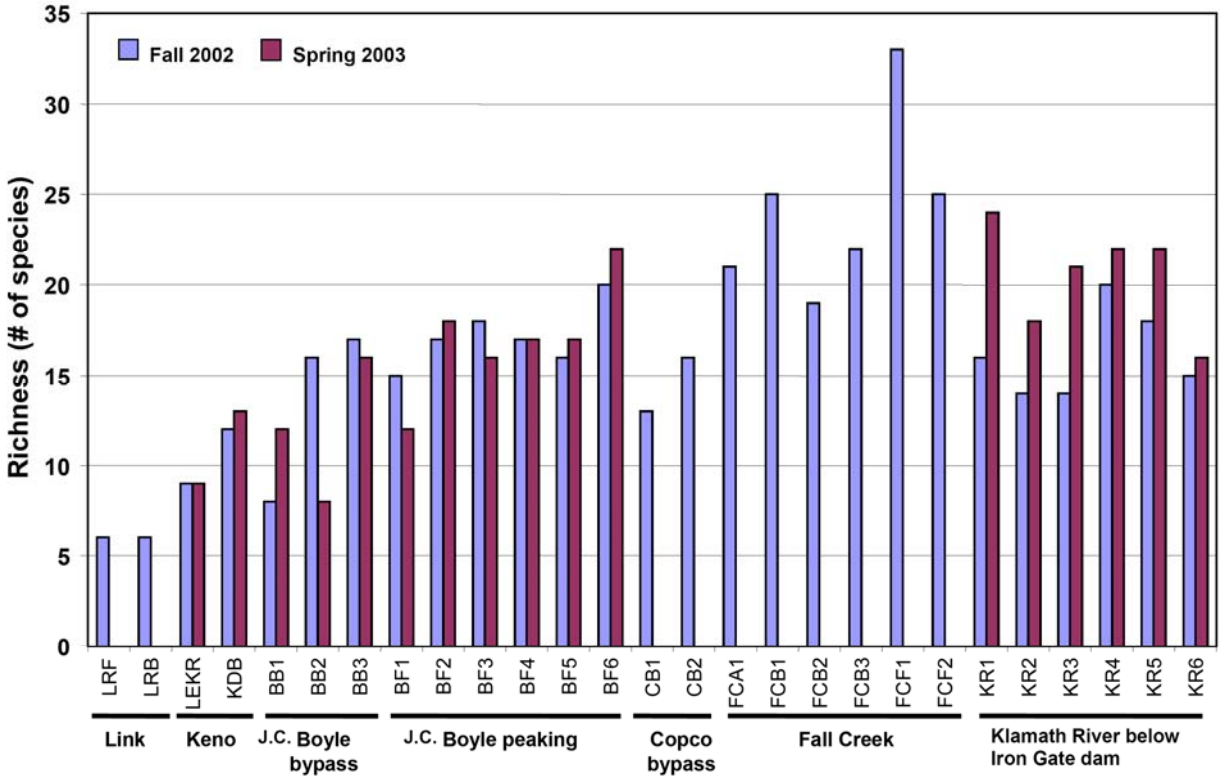


Figure 3-80. Number of species of mayflies, stoneflies and caddisflies (EPT richness) measured during fall 2002 and spring 2003 in the Klamath River between Link River and the confluence with the Shasta River. (Source: PacifiCorp, 2004f)

Table 3-58. Sampling sites where bivalve species were observed during macroinvertebrate sampling and focused bivalve surveys. (Source: PacifiCorp, 2004a, as modified by staff)

Scientific Name	Common Name	Keno Reservoir	Keno Reach	J.C. Boyle Reservoir	J.C. Boyle Bypassed Reach	J.C. Boyle Peaking Reach	Copco Reservoir	Copco Bypassed Reach	Fall Creek	Iron Gate Reservoir	Iron Gate Dam to Shasta River
Musculium lacustre	lake fingernail clam	x		x			x				
Pisidium spp.	unidentified peaclam		x		x	x					
Pisidium casertanum	ubiquitous peaclam				x	x		x	x		x
Pisidium insigne	tiny peaclam								x		
Pisidium ultramontanum	montane peaclam					x					x
Pisidium variabile	triangular peaclam		x	x		x	x				x
Sphaerium securis	pond fingernail clam		x								
Sphaerium simile	grooved fingernail clam	x		x		x				x	
Anodonta oregonensis	Oregon floater[a]	--	x		--	--	--	--	--	--	x
Anodonta californiensis	California floater			x							
Gonidia angulata	western ridgemussel[a]	--	x	--	--	x	--	--	--	--	x

[a] The unionid mussels *Anodonta oregonensis* and *Gonidia angulata* in the Keno, J.C. Boyle peaking, and Iron Gate to Shasta River reaches were identified during a summer, 2003, bivalve field survey that focused only on these three reaches.

3.3.3.2 Environmental Effects

3.3.3.2.1 Instream Flows

Instream flows affect the quantity and quality of habitat available to aquatic species including water depth and velocity, water quality conditions, and the quality of spawning gravel for resident and anadromous species of fish. Flow fluctuations can reduce invertebrate productivity and the available food supply and cause fish stranding. Fry and juvenile fish are especially susceptible to stranding due to their weak swimming ability and preference for shallower, nearshore habitats. In the following sections we evaluate the effect of recommendations related to flows for each project-affected reach from Link River dam to the reach downstream of Iron Gate dam. Monthly flow statistics for releases from each project development are presented in table 3-18.

Link River Flows

PacifiCorp has an agreement with Oregon Fish & Wildlife to maintain an instantaneous flow of 90 cfs downstream of Reclamation's Link River dam. This minimum flow is increased to 250 cfs from July 27 through October 17 to comply with provisions of the 2002 FWS BiOp to protect the federally listed Lost River and shortnose suckers when water quality conditions are adverse. The 2002 FWS BiOp also requires shutdown of West Side development from July 27 through October 17, and that flows passed through the East Side diversion be reduced to 200 cfs at night from July 27 through October 17 to limit sucker entrainment. FWS reports that the minimum flow agreement of 90 cfs has not always been followed, with an estimated 23-30 cfs of flow from leakage and flow through the fish ladder observed on occasion (letter from Interior dated March 27, 2006).

Current ramp rates at Link River dam were put in place in the 1980s through collaboration with Oregon Fish & Wildlife. Ramping rates below Link River dam are limited to 20 cfs per 5 minutes when flows are between 0 and 300 cfs; 50 cfs per 30 minutes when flows are between 300 and 500 cfs; and 100 cfs per 30 minutes when flows are between 500 and 1,500 cfs.

PacifiCorp proposes to decommission the East Side and West Side facilities to eliminate entrainment of federally listed suckers from Upper Klamath Lake. The gates that supply water to the East Side diversion at Link River dam would be rendered inoperable, the back side of the gates would be sealed with concrete, and the existing forebay for each development would be filled. Because the dam is owned by Reclamation, if East Side and West Side developments are decommissioned, PacifiCorp would not by necessity have control over any portion of the flow that passes the dam. Other than rendering the East Side and West Side facilities inoperable, PacifiCorp does not propose any flow-related measures associated with Reclamation's Link River dam.

If East Side and West Side developments are not decommissioned, Oregon Fish & Wildlife recommends that there be no diversions to those developments when flows below Link River dam are 500 cfs or less. NMFS recommends that PacifiCorp consult with them on a flow and facilities operations schedule that minimizes impacts on anadromous fisheries. Oregon Fish & Wildlife and FWS recommend that if the projects are not decommissioned that ramping rates not exceed 1 inch per hour. The Hoopa Valley Tribe recommends that when native salmonid fry and federally listed sucker juveniles are present (about May 1- September 30), ramp rates not exceed 1.2 inches per hour in the bypassed, peaking, or project-regulated reaches. During the rest of the year, ramping would not exceed 2.4 inches per hour. These ramp rates would apply to all project operations including load following, re-regulating, and project start-ups and shutdowns.

NMFS recommends that, if East Side and West Side developments are not decommissioned, PacifiCorp operate hydroelectric facilities and other controlling structures in a manner that avoids fluctuations in river flow, and cease hydroelectric peaking and load following operations.

Our Analysis

Currently, the Link River supports fish populations including blue chub, tui chub, and fathead minnows that are tolerant of high water temperatures, low DO levels, and high pH levels (see table 3-39). Shortnose suckers and Lost River suckers also are present.

PacifiCorp's proposal to decommission East Side and West Side developments would increase the amount of flow in the currently bypassed portion of the Link River, and the recommendation by Oregon Fish & Wildlife to establish minimum flows in the Link River by not diverting flows to the East Side and West Side developments when flows are 500 cfs or less would both benefit aquatic resources by reducing the incidence of reach de-watering and increase available habitat for fish in the Link River. NMFS' recommendation for consultation would similarly likely result in an increase in minimum flow releases over existing conditions and improve habitat quality.

Increasing the minimum flow in the Link River, however, could conflict with the provision in NMFS and Interior's preliminary fishway prescription to construct a new fish screen and bypass facility at East Side and West Side developments as close as possible to the beginning of each diversion for effective downstream passage of Chinook salmon, steelhead, Pacific lamprey, federally listed suckers, and rainbow trout. As we discuss in section 3.3.3.2.2, *Fish Passage*, the intent of this facility would be to collect outmigrating anadromous fish to allow them to be transported downstream during periods when water quality conditions are adverse in Keno reservoir. If this facility were constructed, a minimum flow release provided from Link River dam would allow outmigrating smolts to bypass the screening facility and expose them to poor water quality conditions in Keno reservoir, and would likely reduce their survival rate. PacifiCorp's alternative prescription also includes a provision to construct a smolt collection facility upstream of J.C. Boyle dam if studies indicate that it is possible to establish self-sustaining runs of anadromous fish. This facility could potentially be located at Link River dam to enable the transport of outmigrating smolts past Keno reservoir. We conclude that increasing the minimum flow release at Link River dam could impede restoration of anadromous fish to areas upstream of Link River dam if a smolt collection facility were to be constructed at East Side or West Side developments, unless the screening facility was expanded in size to accommodate both the minimum and powerhouse flows.

Oregon Fish & Wildlife and FWS recommend a maximum ramp rate of 1 inch per hour and 300 cfs per day if East Side and West Side developments are not decommissioned, and the Hoopa Valley Tribes' recommendation is for 1.2 inches per hour or 2.4 inches per hour depending on the time of year. Meeting this ramping rate would likely require modifications to the civil structures at East Side and West Side developments. A downramp rate of 2 inches per hour is generally regarded as a conservative rate for the protection of salmon fry under most conditions (Hunter, 1992) and is often recommended for non-peaking hydroelectric projects. However, there is no evidence in the record that current downramp releases from East Side and West Side developments are resulting in fish stranding, and we consider the existing ramp rates to be sufficiently gradual that adverse effects are unlikely. Link River dam is not part of the existing or proposed project, and therefore the Commission has no authority to control releases at the dam, other than by modifying operations at the powerhouses or intake canals. We consider it most appropriate, and likely much more feasible, for Reclamation to be responsible for maintaining protective ramping rates of flows released at Link River dam by operating gates at the dam. However, coordination of operations at Link River dam with operation of East Side and West Side developments could be addressed in a project operations management plan, should these developments not be decommissioned

Keno Dam

Although Keno development does not provide generation, it does serve to regulate the reservoir elevations in Keno reservoir to support irrigation withdrawals. The Keno reservoir receives nearly 80 percent of its inflow from the Link River, with agricultural returns accounting for about 20 percent of flow, and municipal and industrial inflows about 1 percent. Inflow quantities may vary widely on a day-to-day or week-to-week basis. PacifiCorp operates Keno reservoir in accordance with an agreement with

Reclamation that specifies that water surface elevation of Keno reservoir be maintained between 4,085.0 and 4,086.5 feet. At the request of irrigators, PacifiCorp generally operates Keno dam to maintain the reservoir at elevation 4,085.4 +/-0.1 foot from October 1 to May 15 and elevation 4,085.5 +/-0.1 foot from May 16 to September 30 (see figure 3-8) to allow consistent operation of irrigation canals and pumps. PacifiCorp also has an agreement with Oregon Fish & Wildlife to release a minimum flow of 200 cfs at the dam. PacifiCorp currently adheres to a 500 cfs per hour ramp rate at Keno dam, which equates to about 9 inches per hour. PacifiCorp proposes to exclude Keno dam from the project (see section 4.8, *Keno Development Analysis*), and has not proposed any measures related to minimum flows or ramping rates for the development.

NMFS, FWS, Oregon Fish & Wildlife, and Cal Fish & Game recommend that Keno development be operated as a modified run-of-river facility and not be used to re-regulate flows to support peaking operations at downstream developments. They recommend that PacifiCorp hold river flows below Keno dam to within 10 percent of the measured project inflow, including inflows from Link River and irrigation return flows, less irrigation withdrawals. FWS recommends that outflows be based on a 3-day running average of the combined flow from Link River and the Reclamation project (including Klamath Straits drain, Lost River, and North/Ady canal). Oregon Fish & Wildlife and Cal Fish & Game include a recommended minimum flow release of 625 cfs below Keno dam, or inflow if inflows are less than 625 cfs, with flows above 625 cfs to be held within 10 percent of inflow. The Hoopa Valley Tribe recommends that PacifiCorp discharge a continuous minimum flow of 500 cfs or 70 percent of inflow to the project, whichever is greater, except that the minimum flow would be equal to inflow when inflows are less than 500 cfs.

Oregon Fish & Wildlife recommends that controllable ramp rates at Keno not exceed 1 inch per hour at any time, with a maximum daily controllable ramp rate of no more than 300 cfs per day upramp or downramp. Ramp rates would apply to all operations, including start-ups and planned shutdowns, load following and re-regulating. As previously described, the Hoopa Valley Tribe recommends a ramping rate that ranges from 1.2 to 2.4 inches per hour.

Our Analysis

The fish population in the Keno reach is dominated by marbled sculpin, fathead minnows, blue chub, speckled dace, and tui chub (see table 3-41). Of the federally listed sucker species, only the Lost River sucker was observed (in 1 out of 2 years of sampling conducted) by PacifiCorp in the Keno reach. Although summer water temperatures in the Keno reach are generally warmer than optimum for trout (the 7-day mean maximum daily water temperature in the Keno reach can rise as high as 25°C), turbulence maintains DO levels that support a fishery for rainbow trout, and the Keno reach is a popular area for angling in the Klamath River. Catch records indicate good angler success, and Oregon Fish & Wildlife manages the trout fishery in the Keno reach for natural production.

Flows in the Keno reach can fluctuate on a 24-hour basis, particularly in average or above-average flow years (figures 3-81 through 3-83). Although available information indicates that the Keno reach already supports a high quality trout fishery, decreasing the magnitude of flow fluctuations by reducing ramping rates from the current 9 inch per hour rate and establishing minimum flows that are greater than the current minimum flow of 200 cfs would provide more stable habitat for trout and suckers present in the reach. Reducing flow fluctuations may also help increase productivity of benthic invertebrates in the fluctuation zone, and provide more prey for the trout fishery there. Regulating the minimum flow releases based on a 3-day running average of the inflow would further help decrease the daily magnitude of fluctuations caused by irrigation withdrawals and return flows.

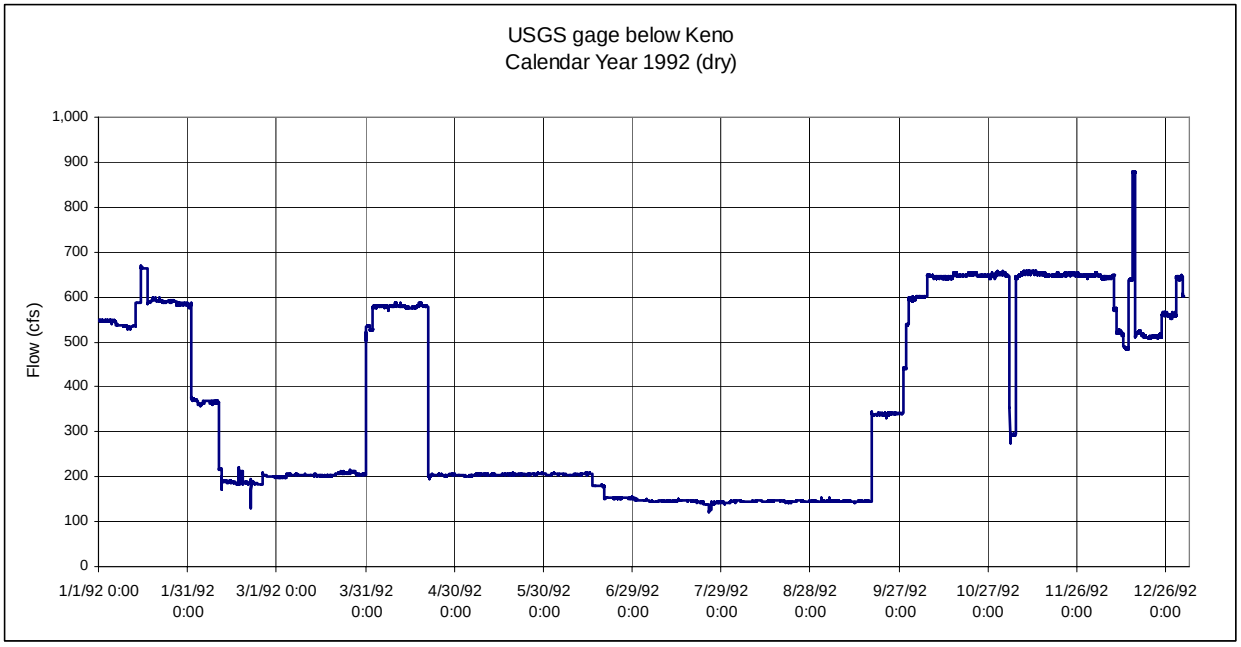


Figure 3-81. Flows measured below Keno dam in 1992 (dry year). (Source: PacifiCorp, 2005f; USGS, 2006a)

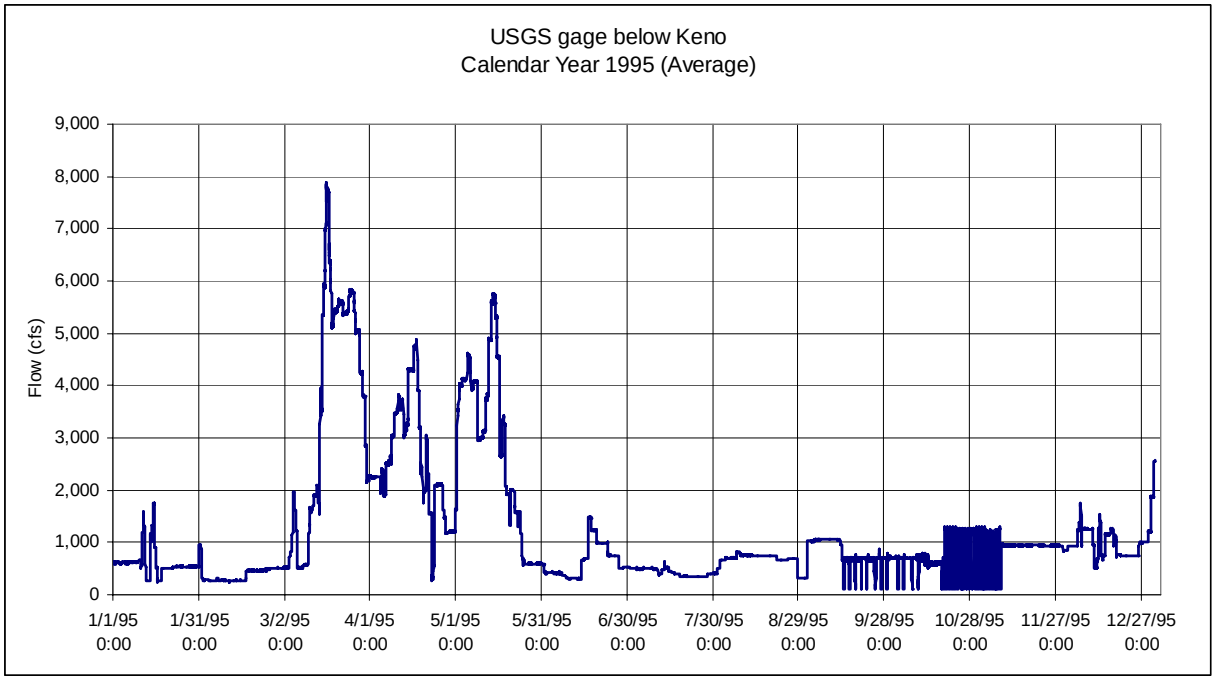


Figure 3-82. Flows measured below Keno dam in 1995 (average year). (Source: PacifiCorp, 2005f; USGS, 2006a)

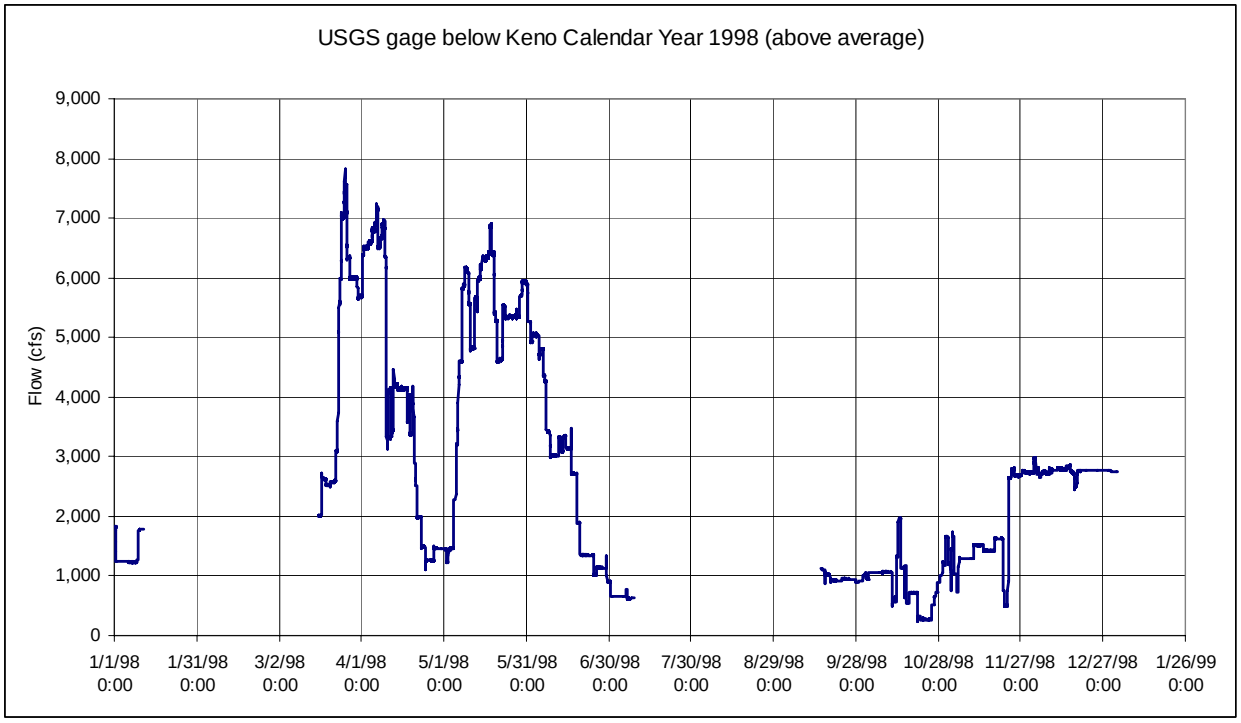


Figure 3-83. Flows measured below Keno dam in 1998 (above average year). (Source: PacifiCorp, 2005f; USGS, 2006a)

J.C. Boyle Bypassed Reach

The river channel in the J.C. Boyle bypassed reach is about 100 feet wide, consisting of rapids, runs, and pools among large boulders with some large cobbles interspersed. Gravel is scarce, and the gradient is relatively steep (see figure 3-2). When spill from the dam is substantial (as typically occurs on average from 5 to 8 days a month during February through May as shown in table 3-19), habitat in the bypassed reach consists of a series of rapids and fast runs.

Currently, PacifiCorp releases a 100 cfs minimum flow at the dam, and of this flow approximately 80 cfs comes from the J.C. Boyle fish ladder and 20 cfs from the juvenile bypass facility. An additional 220 to 250 cfs of spring flow accrues in the upper mile of the bypassed reach, beginning about 0.5 mile downstream from the dam.

PacifiCorp proposes to continue the minimum 100 cfs flow release at the dam, and to construct a gage at the top of the bypassed reach to monitor flows. PacifiCorp also proposes to release an additional 100 cfs from either J.C. Boyle dam into the bypassed reach or at the J.C. Boyle powerhouse. If the additional 100 cfs release were made from the dam it would result in a total flow of about 420 to 450 cfs of flow at the lower end of the bypassed reach.

Downramping in the J.C. Boyle bypassed reach does not occur for power production purposes, but occurs primarily when coming off of spill mode or during maintenance events, both of which are infrequent. The existing license includes a ramp rate restriction of 9 inches per hour, which is equivalent to about 700 cfs per hour when river flows are between 400 and 3,000 cfs, as measured at USGS gage no. 11510700 just downstream of the powerhouse. Standard operating procedure, however, is to change flows by 135 cfs per 10 minutes (or 810 cfs per hour), which is equivalent to about 7.2 inches per hour at the USGS gage. PacifiCorp proposes to limit downramping in the bypassed reach to 150 cfs per hour (about 1.2 inches per hour), except for flow conditions beyond the project's control. PacifiCorp also proposes to conduct downramping at night to the extent possible.

Oregon Fish & Wildlife, NMFS, and Cal Fish & Game recommend that PacifiCorp release a minimum flow of 640 cfs or 40 percent of inflows, whichever is more, into the J.C. Boyle bypassed reach. If inflows are less than 640 cfs, all available flow would be released into the bypassed reach. They further recommend that inflow be computed as a running average of flows at the Keno gage (no. 11505900) added to flows at Spencer Creek gage (no. 11510000) during the prior 3 days. The Bureau of Land Management specifies a similar flow, except that the minimum flow threshold would be 470 cfs rather than 640 cfs.

The Hoopa Valley Tribe recommends that PacifiCorp discharge a continuous minimum flow of 500 cfs or 70 percent of inflow to the project, whichever is greater. The allowed minimum flow would be reduced to inflow when inflows are less than 500 cfs.

Oregon Fish & Wildlife recommends that controllable upramp and downramp rates not exceed 1 inch per hour or 300 cfs per day. The Bureau of Land Management specifies that upramp and downramp rates not exceed 2 inches per hour (measured at a new gage to be installed downstream of J.C. Boyle dam at RM 225) during controlled flow events, except during implementation of the seasonal high flow. As previously described, the Hoopa Valley Tribe recommends a ramping rate that ranges from 1.2 to 2.4 inches per hour.

Our Analysis

The fish community in the J.C. Boyle bypassed reach is dominated by rainbow trout, speckled dace, and marbled sculpin (table 3-43). This reach is popular for trout fishing (this is also true for the Keno and J.C. Boyle peaking reaches). Catch records indicate good angler success, although fish in this reach are typically smaller than fish caught in the Keno reach and rarely exceed 16 inches.

The influx of about 220 to 250 cfs of cool water from springs in the J.C. Boyle bypassed reach combined with the minimum flow release of 100 cfs provide much cooler water temperatures in the lower 3 miles of the bypassed reach compared with the flows released from J.C. Boyle dam and in other downstream reaches (table 3-59 and figure 3-84). The colder water from the bypassed reach then flows into the J.C. Boyle peaking reach, and serves to cool the water in the peaking reach, especially during the night when flows from the powerhouse are reduced during peaking operations.

The various proposals to increase minimum flows releases in the bypassed reach by 100 cfs to 640 cfs would affect the current temperature regime as well as the physical amount of habitat for trout in the reach. Increasing the volume of warm water released from J.C. Boyle reservoir would decrease the cooling effect of the spring water accretion flows in the reach (table 3-59). Although rainbow trout in the Klamath basin are more tolerant of higher temperatures than most other salmonids (Behnke, 1992), the springs in the J.C. Boyle bypassed reach currently provide water temperatures that are near-optimal for salmonids (13 to 16°C [Behnke, 1992]), and thus likely provide thermal refugia for trout throughout the summer months.

The results of an instream flow study conducted by PacifiCorp show that the amount of physical habitat as represented by weighted usable area (WUA)[74] available to trout in the bypassed reach generally increases as flows increase up to 400 cfs for the juvenile and adult life stages, and then levels off at further flow increases. WUA for fry increases up to 800 cfs before leveling off (figure 3-85, table 3-59). Physical habitat for trout juveniles and adults reaches its maximum at 650 and 3,000 cfs, respectively.

[74]WUA is a measure of physical habitat available at a specified streamflow for a given life stage and species of fish.

Table 3-59. Estimated water temperatures, wetted perimeter, and modeled rainbow trout WUA in the lower J.C. Boyle bypassed reach based on the volume of water released at J.C. Boyle dam. (Source for WUA: PacifiCorp, 2005m, and water temperatures estimated by staff)

Discharge at J.C. Boyle dam (cfs)	**Total flow after spring flow accretion (cfs)**	**Estimated[a] temp in lower end of bypassed reach (ºC)**	**Estimated[b] average wetted area (square ft)**	**Rainbow Trout WUA (square ft)[b]** *[percent of maximum WUA[c]]*		
				Fry[c]	***Juveniles[c]***	***Adults[c]***
100 cfs (existing)	335	14.3	76,542	4,638 [66]	14,367 [89]	17,553 [82]
200 cfs (PacifiCorp proposed if 200 cfs released from dam)	435	16.1	86,420	5,084 [72]	15,184 [94]	18,740 [88]
470 cfs (Bureau of Land Management specified)	705	18.3	95,454 *(at 450 cfs)*	6,050 [86]	16,068 [99]	19,737 [93]
500 cfs (Hoopa Valley Tribe recommended)	735	18.5	95,804	6,220 [88]	16,127 [99]	19,756 [93]
640 cfs (Oregon Fish & Wildlife, NMFS, Cal Fish & Game recommended)	875	19.0	99,935 *(at 650 cfs)*	6,674 [95]	16,211 [100]	19,804 [93]

[a] Temperatures shown reflect mixing only, and assume dam release flow temperatures of 22ºC, spring accretion flow temperatures of 11ºC, and spring accretion flow of 235 cfs.

[b] Data are from PacifiCorp (2005m).

[c] Maximum modeled WUA for fry at 1,000 cfs (7,050 square feet), for juveniles at 650 cfs (16,211 square feet), and for adults at 3,000 cfs (21,321 square feet).

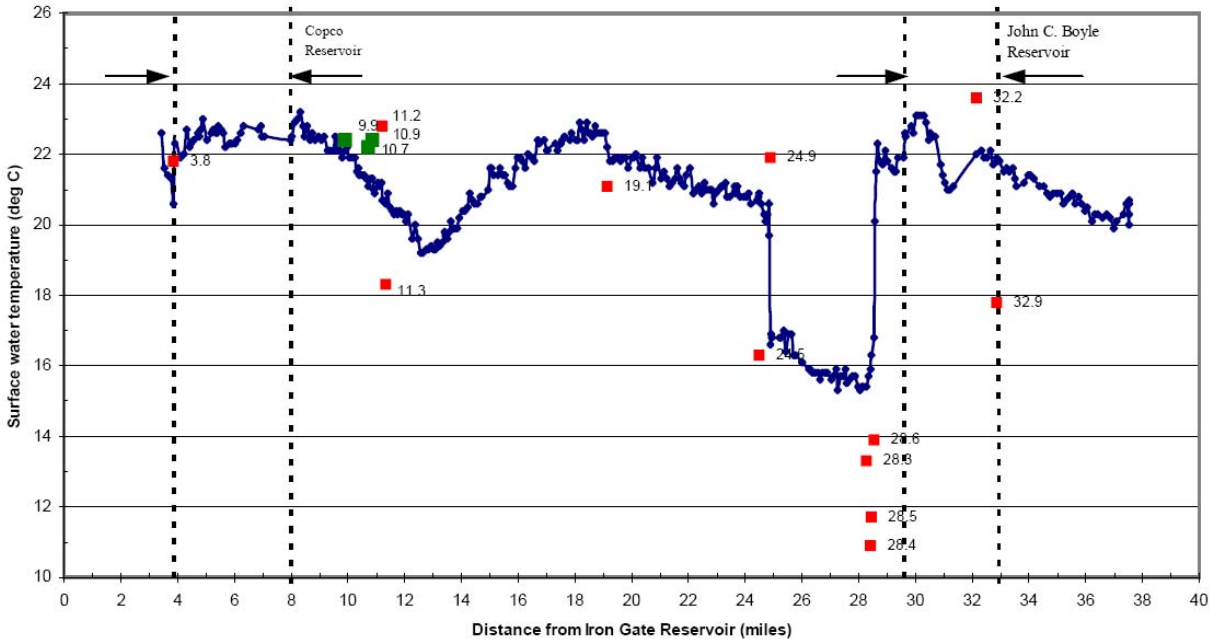


Figure 3-84. Median channel temperatures versus river mile for Klamath River, CA/OR, along with the location of surface water inflows (represented by red squares) on July 15, 2001. (Source: Watershed Sciences, 2003)

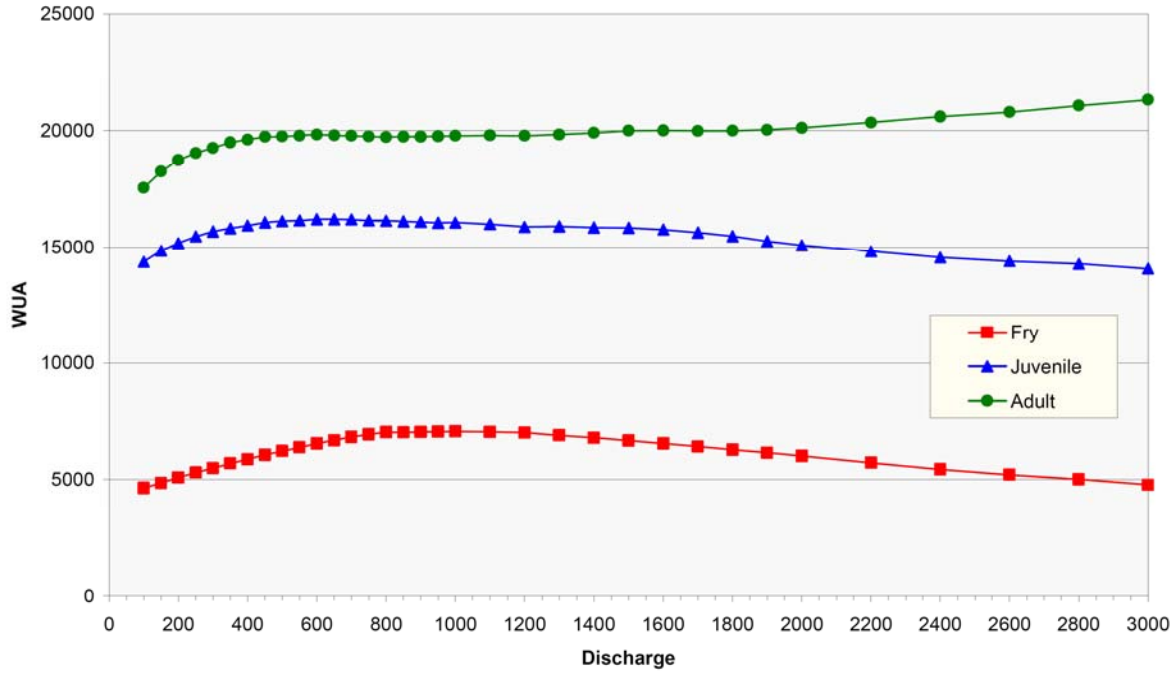


Figure 3-85. Rainbow trout WUA for the J.C. Boyle bypassed reach. Discharge equals release from J.C. Boyle dam. (Source: PacifiCorp, 2005m)

Although the results of PacifiCorp's instream flow study indicate that higher instream flow releases would increase the amount of physical habitat that is available to rainbow trout in the bypassed reach, these higher release flows would also increase water temperatures in the spring-influenced portion

of the bypassed reach. As shown in figure 3-84, under existing conditions, water temperatures in mid-July decreased from around 22°C below J.C. Boyle dam to 15.5°C about 1 mile downstream of the dam as a result of accretion of cool groundwater from spring sources. Downstream of this point, water temperatures increased to about 16.5°C by the downstream end of the bypassed reach. To evaluate the effect of increased dam releases on water temperatures, we calculated the water temperature that would result from mixing different volumes of release flows at 22°C with an assumed accretion flow of 235 cfs at 11°C. Using this method, we estimated that the temperature below the primary area of groundwater accretion would be increased from 14.3°C at the 100 cfs release flow to 16.1°C at a 200 cfs release flow, which is still nearly within the optimal range of 13 to 16°C for salmonid growth given by Behnke (1992). Further increases in dam releases would raise water temperatures below the accretion area to 18.3°C with the 470 cfs release specified by the Bureau of Land Management to 19.0°C for the 640 cfs release recommended by Oregon Fish & Wildlife, NMFS, and Cal Fish & Game. We conclude that a release of 200 cfs at the dam would strike a reasonable balance between temperature and physical habitat needs for trout, because it would increase the amount of physical habitat for all three life stages of trout without causing water temperatures to exceed the optimal growth range for salmonids.

We acknowledge that higher flow releases may provide an additional benefit to rainbow trout in this reach if the optimal temperature for growth of Klamath River rainbow trout is higher than the 13 to 16°C range given by Behnke (1992). However, increasing minimum flow releases beyond 200 cfs could compromise the suitability of the reach downstream of the springs as holding habitat for adult spring Chinook salmon and steelhead should these species be restored to this reach. Although spring Chinook salmon have been observed holding in pools with water temperatures exceeding 20°C (West, 1991), there is little doubt that increased metabolic rates at high temperatures would act to increase the expenditure of energy reserves for these fish, which hold in fresh water for an extended time period prior to spawning. Poole et al. (2001) reports that gamete viability of anadromous salmon can be reduced at temperatures exceeding 13 to 16°C, and that the risk of increased disease rates is elevated at temperatures exceeding 14 to 17°C and is likely to be severe at temperatures exceeding 18 to 20°C. Although the ALJ concluded that implementation of higher minimum flows would not cause complete mixing of warm and cool water and would still provide a substantial temperature refugia, we conclude that the high degree of turbulence in this reach would cause a high degree of mixing. As a result, during the summer when spring Chinook salmon and steelhead would use the refugia for holding, water temperatures in nearly all of the areas would exceed the ranges given by Poole et al. (2001) and would likely increase disease risk and lower gamete viability.

PacifiCorp provided a figure showing WUA versus flow relationships for juvenile Chinook salmon, coho salmon, and steelhead trout in its comments on the draft EIS (figure 3-86). The WUA versus flow relationship for juvenile coho salmon and steelhead shows little variation over the range of flows proposed by PacifiCorp and recommended by other stakeholders. WUA for juvenile Chinook salmon is at a maximum for flows in the 200 to 400 cfs range and then decreases by about 25 percent between 400 and 1,400 cfs. PacifiCorp did not indicate whether the discharges shown in the x-axis of this figure represent flows released from the dam. Regardless of whether the figure includes the spring inflows that occur in the bypassed reach, minimum flow releases in the vicinity of 200 to 250 cfs would provide near-optimal habitat for juvenile Chinook salmon, coho salmon, and steelhead.

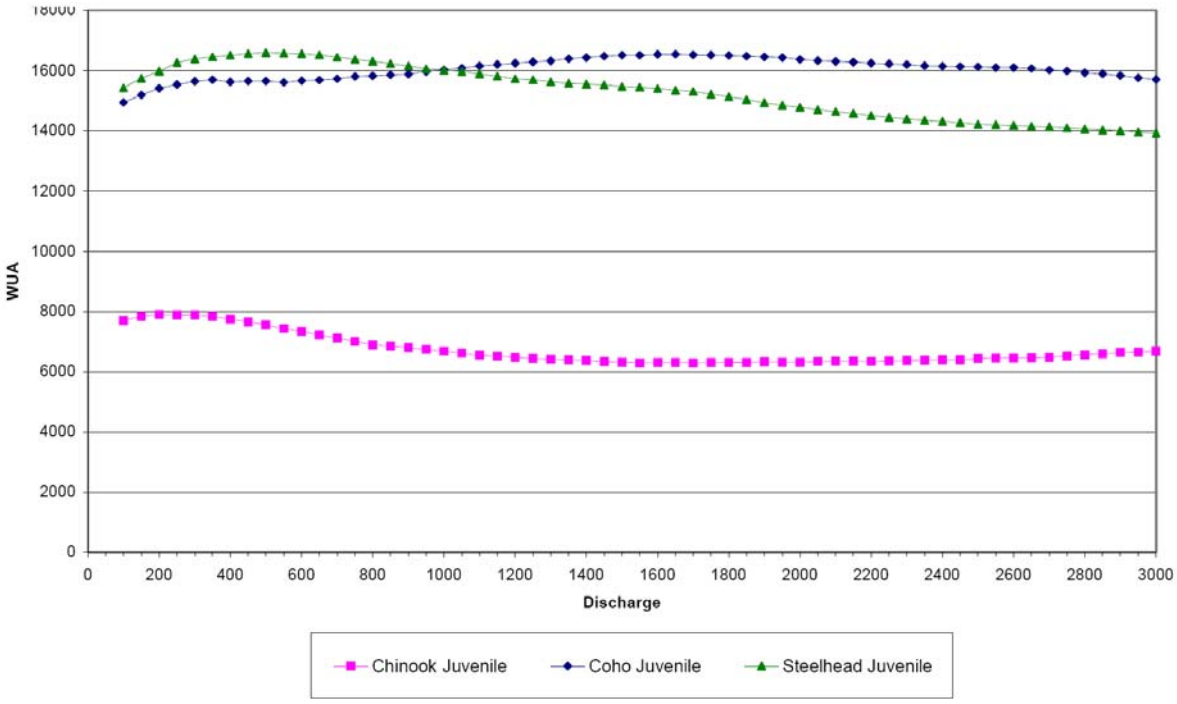


Figure 3-86. Weighted usable area (WUA) as a function of discharge (cfs) in the J.C. Boyle bypassed reach for Chinook salmon, coho salmon, and steelhead juveniles. (Source: PacifiCorp comments on the draft EIS, December 1, 2006)

Flow downramping has the potential to strand fish in areas of the channel that are relatively low-gradient, or where pockets or side channels exist in the river channel. Fry and smaller juvenile fish are the most vulnerable to potential stranding due to weak swimming ability and preference for shallower, nearshore habitats. River channel configuration, channel substrate type, time of day, and flow level before downramping are also factors that determine stranding incidence. Trout spawn in the J.C. Boyle bypassed reach, and trout fry occur along the stream margins from early June through the summer, thus it is possible that some stranding of small fish could occur at the current downramp rates under certain flow conditions and times of the year. When release flows drop from about 1,000 cfs to the 100 cfs minimum flow, dewatering of streambed areas and a few side channels can pose a risk of stranding to small fish.

PacifiCorp indicates that under current conditions, downramping at J.C. Boyle dam occurs rarely, primarily after high flow events, which as indicated in table 3-19, mostly occur prior to fry being present. PacifiCorp's proposed downramp rate of 150 cfs reflects a substantial reduction from the current licensed rate of 9 inches (approximately 700 cfs) per hour. We estimate that the proposed rate of flow change would equate to a stage change of approximately 1.9 inches per hour, which is similar to the 2 inch per hour ramping rate specified by the Bureau of Land Management. Compared to current operations, the proposed ramping rate would reduce the risk of stranding fry and juvenile fish, and would provide a more gradual transition time for adult trout to relocate as river levels change. This could be important during pre-spawn staging and during spawning. PacifiCorp also proposes that downramping occur at night to the extent possible as a result of studies indicating that juvenile trout are less vulnerable to stranding at night during winter conditions (PacifiCorp, 2004e). During such cold-water winter conditions, juvenile trout tend to hide in interstitial areas of substrate during the day, whereas during night they move out of the substrate and can respond to dropping flows.

Oregon Fish & Wildlife and the Hoopa Valley Tribe's recommended ramping rate of 1 inch per hour reflects a more substantial decrease in current ramping rate of 9 inches per hour, and is more restrictive than PacifiCorp's proposed ramping rate of 1.9 inches per hour. However, stranding has not been identified as a problem in this reach, and, as stated above, ramping in this reach is an infrequent event, and a downramp rate of 2 inches per hour is generally regarded as a conservative rate for the protection of salmon and trout fry under most conditions.

J.C. Boyle Bypassed Reach Seasonal High Flows

Oregon Fish & Wildlife recommends that, at least once a year between February 1 and April 15, no water be diverted to the J.C. Boyle or Copco No. 2 power canals when inflow to J.C. Boyle reservoir (including Spencer Creek) exceeds 3,300 cfs, and that this diversion cessation be maintained for at least 7 full days. Oregon Fish & Wildlife recommends the downramp rate for this seasonal high flow not exceed 2 inches per hour or 300 cfs per 24 hour period, as measured at a new gage to be installed downstream of J.C. Boyle dam. NMFS and Cal Fish & Game make the same recommendation, except they do not specify an hourly ramp rate. The Bureau of Land Management modified 4(e) conditions specify that PacifiCorp develop and implement an appropriate ramp rate to follow after the seasonal high flow to prevent stranding fish in the J.C. Boyle bypassed reach.

Our Analysis

Provision of a seasonal high flow as recommended by the agencies could help to ensure that spawning areas used by trout remain sufficiently free of silt to support egg incubation and trout recruitment. However, as shown in table 3-19, on average, spill events of up to 8 days a month that release up to 2,803 cfs of flow occur under existing conditions. Flows in this range should be sufficient to flush fine-grained sediments from spawning gravels in most years. Furthermore, the bypassed and peaking reaches currently support high quality trout fisheries, as reflected by angler catch rates reported by Oregon Fish & Wildlife and by PacifiCorp (tables 3-60 and 3-61, respectively). PacifiCorp reports that the population of rainbow trout exceeding 7.8 inches was estimated to be 890 fish per mile in the upper 6 miles of the peaking reach and 1,911 fish per mile in the next 5 miles of the river in 1984. They report that these population densities are comparable to those in the lower Deschutes River, which is noted to be one of the most productive rivers in the state. Furthermore, PacifiCorp proposes to augment spawning gravel in the bypassed reach and to eliminate agricultural diversions on Shovel and Negro creeks, which should enhance recruitment of trout fry from both of the locations where most of the spawning between J.C. Boyle and Copco No. 1 dams is thought to occur.

Table 3-60. Rainbow trout catch per hour from Oregon Fish & Wildlife angler survey data from 1978 to 1984 for the Keno, J.C. Boyle bypassed, and J.C. Boyle peaking reaches. (Source: PacifiCorp, 2004e)

	Reach		
Year	**Keno**	**J.C. Boyle Bypass**	**J.C. Boyle Peaking**
1979	0.33	0.41	0.74
1980	0.27	0.67	0.71
1981	0.09	0.47	1.31
1982	0.13	0.87	0.56
1983	0.08	0.62	0.56
1984	0.49	0.69	0.77
Average	0.23	0.62	0.78

Table 3-61. Rainbow trout catch per hour from PacifiCorp hook-and-line sampling conducted in 2002 in the Keno, J.C. Boyle bypassed, and J.C. Boyle peaking reaches. (Source: PacifiCorp, 2004e)

Reach	Total	Spring	Summer	Fall	Upper	Lower
Keno	0.6	0.6	0.2	1.1	0.5	0.8
J.C. Boyle Bypass	1.1	0.8	0.7	1.3		
J.C. Boyle Peaking	1.2	0.9	1.1	2.7	1.1	1.3

J.C. Boyle Peaking Reach

Flows passing from the J.C. Boyle bypassed reach and those released from the J.C. Boyle powerhouse affect aquatic habitat in the 17.3-mile-long reach between the powerhouse and Copco reservoir, referred to as the J.C. Boyle peaking reach. The upstream 11.1 miles of this reach are in Oregon, and this segment has been federally designated as a Wild and Scenic River (discussed further in section 3.3.6, *Recreational Resources*, and section 3.3.7, *Land Use and Aesthetic Resources)*. The downstream 6.2 miles are in California, and this segment is designated by Cal Fish & Game as a Wild Trout Area. Both sections are managed for wild trout.

PacifiCorp proposes to limit flow upramp rates to 9 inches per hour and downramp rates to 9 inches per hour for flows exceeding 1,000 cfs, and 4 inches per hour for flows less than 1,000 cfs in the J.C. Boyle peaking reach. Furthermore, it proposes to limit the maximum daily flow change to 1,400 cfs as measured at USGS gage no. 11510700 downstream of the J.C. Boyle powerhouse. This limit of the total flow change to 1,400 cfs per 24-hour period would eliminate full two-unit peaking (420 to 3,420 cfs at the gage), but one-unit peaking still would occur. When flow conditions permit, PacifiCorp would shift from one-unit continuous operation to two-unit peaking operation. PacifiCorp also proposes to install synchronized bypass valves on each of the two J.C. Boyle powerhouse units to eliminate use of the emergency overflow spillway which has caused extensive erosion (see section 3.3.1, *Geology and Soils*). Installation of the bypass valves would help to ensure ramping rates can be met when a unit trips off-line.

PacifiCorp also proposes to increase the current 100 cfs minimum flow release into the peaking reach by releasing a minimum of 200 cfs plus J.C. Boyle bypass accretion as measured at the USGS gage downstream of the J.C. Boyle powerhouse (no. 11510700). This would provide a minimum flow of about 420 to 450 cfs in the J.C. Boyle peaking reach. The new minimum flow would be met through an additional release of 100 cfs from J.C. Boyle dam or a release of 100 cfs at the powerhouse (plus the current release of 100 cfs from J.C. Boyle dam and 220 to 250 cfs from accretion in the bypassed reach).

NMFS recommends that PacifiCorp operate the J.C. Boyle development in run-of-river mode to protect fish and wildlife resources, with gages installed where needed to monitor inflow and outflow from each facility. Cal Fish & Game also recommends that PacifiCorp operate the J.C. Boyle development in run-of-river mode, with no peaking operations, in conjunction with meeting minimum target flows.

Oregon Fish & Wildlife and Cal Fish & Game recommend ramp rates of 1 inch per hour in the peaking reach. The Bureau of Land Management specifies that PacifiCorp not exceed upramp or downramp rates of 2 inches per hour as measured at the existing USGS gage downstream of the J.C. Boyle powerhouse during controlled flow events (e.g., scheduled maintenance, power generation, and changes in minimum flow requirements), except during implementation of seasonal high flow releases. As previously stated, the Hoopa Valley Tribe recommends a ramping rate from 1.2 to 2.4 inches per hour.

Oregon Fish & Wildlife recommends that PacifiCorp provide a minimum flow of 720 cfs to the peaking reach. Cal Fish & Game recommends a minimum flow to the peaking reach of 720 cfs, or inflow if inflow is less than 720 cfs. The Hoopa Valley Tribe recommends that PacifiCorp discharge a continuous minimum flow of 500 cfs or 70 percent of inflow to the project, whichever is greater. The allowed minimum flow would be reduced to inflow when inflows are less than 500 cfs.

The Bureau of Land Management specifies that PacifiCorp operate the J.C. Boyle development to provide a streamflow of 1,500 to 3,000 cfs to the peaking reach a maximum of once a week, with a priority set for Saturday, Sunday, and then Friday.

Our Analysis

The J.C. Boyle powerhouse is typically operated as a peaking facility. Under current operations, when inflow to J.C. Boyle reservoir is below 3,000 cfs, water is typically stored at night and flows during the day are ramped up to either one unit operation (up to 1,500 cfs) or two unit operation (typically 2,750 cfs). Hourly flow fluctuations that occurred in the J.C. Boyle peaking reach in 3 recent years representing dry (1992), average (1995), and wet (1998) conditions are shown in figure 3-87. When ramping is initiated at the J.C. Boyle powerhouse it generally takes 5 to 6 hours for the flow change to arrive at Copco reservoir, 16 miles downstream. Current rates of stage decline are generally between 4.8 and 9 inches per hour (PacifiCorp 2004e).

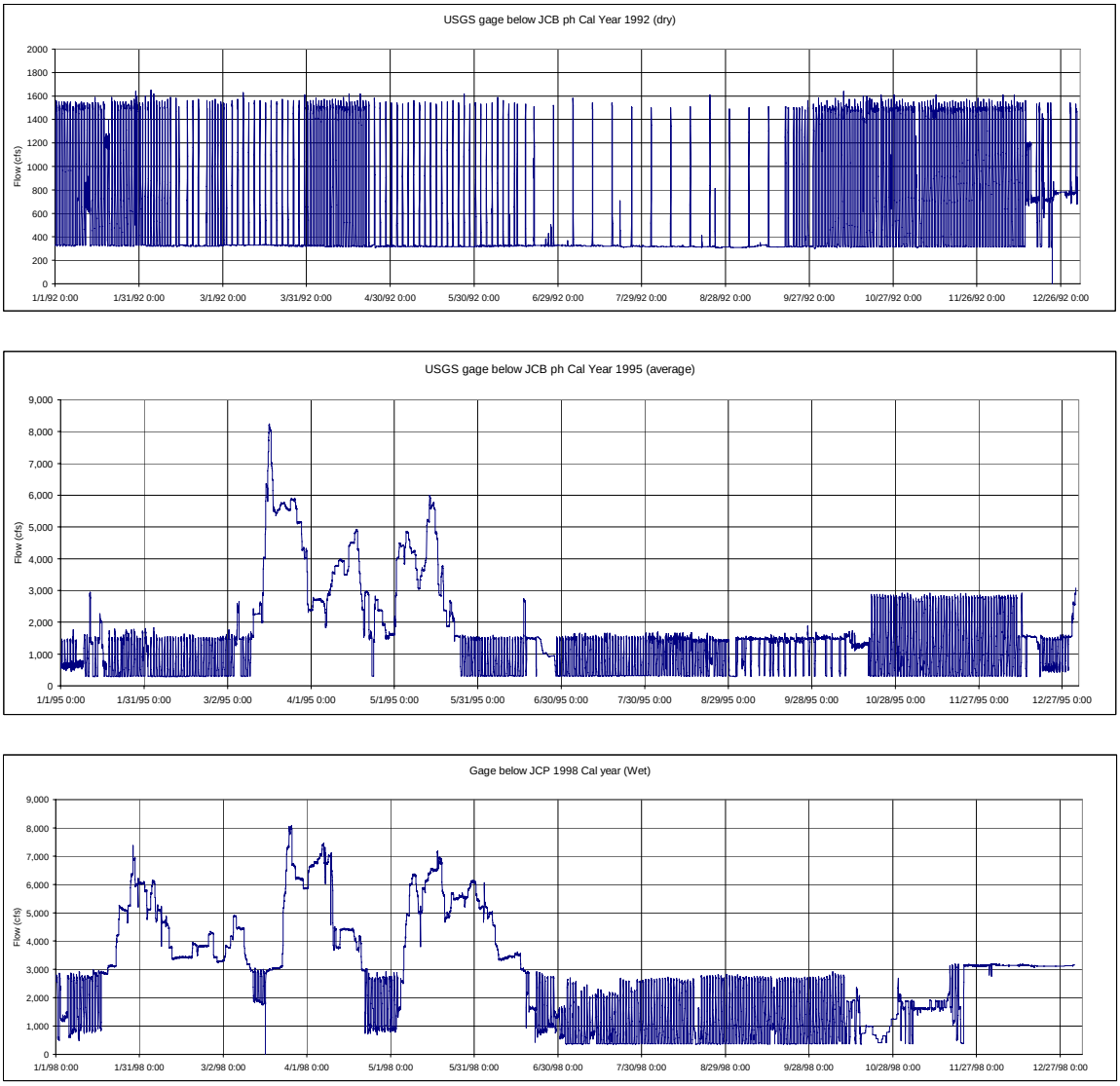


Figure 3-87. Hourly flows in the J.C. Boyle peaking reach for representative dry (1992), average (1995), and wet (1998) years. (Source: USGS, 2006a, as modified by staff)

PacifiCorp conducted several different studies to evaluate the effect of peaking operations on aquatic resources in the J.C. Boyle peaking reach, including an instream flow analysis to evaluate effects on habitat for trout and suckers, a wetted perimeter analysis to evaluate potential effects on invertebrate production, a bioenergetics study, and stranding surveys. However, agency comments on the flow modeling indicated there was disagreement on the modeling approach used by PacifiCorp to model rainbow trout habitat, and none of the stakeholders relied on the results of the instream flow study to support their flow recommendations. Accordingly, we focus most of our analysis of effects on food (invertebrate) production and stranding potential.

Figure 3-88 shows rainbow trout habitat (WUA) versus flow relationships developed during the instream flow study. The habitat versus flow relationship for trout adult and juvenile WUA in the J.C. Boyle peaking reach follow the same general pattern – a gradual increase before leveling off in the 400 to 600 cfs range then declining over the upper range of flows. The study results indicate that the proposed base (minimum) flow[75] of 420 to 450 cfs would provide 64 percent, 100 percent, and 97 percent of the maximum modeled WUA for fry, juvenile, and adult trout, respectively (table 3-62). Increasing minimum flows up to 720 cfs would provide only minimal changes in WUA compared to the proposed minimum flow.

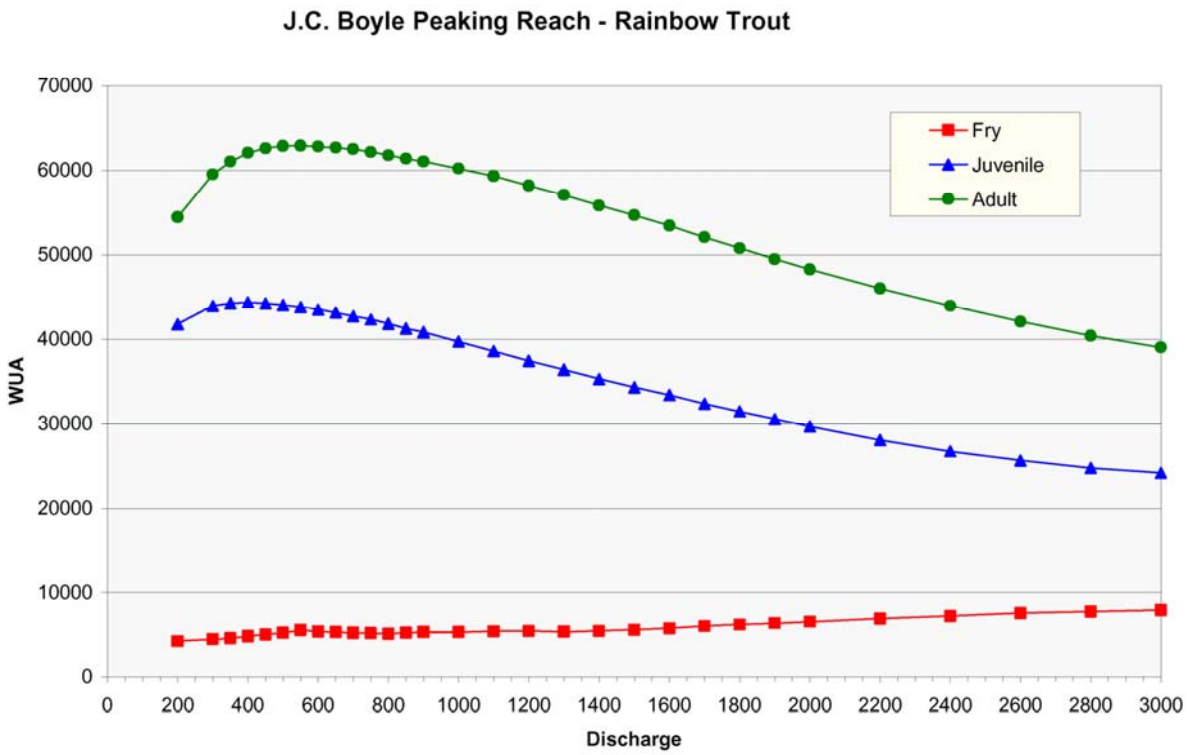


Figure 3-88. Rainbow trout WUA versus discharge for the J.C. Boyle peaking reach. (Source: PacifiCorp, 2005m)

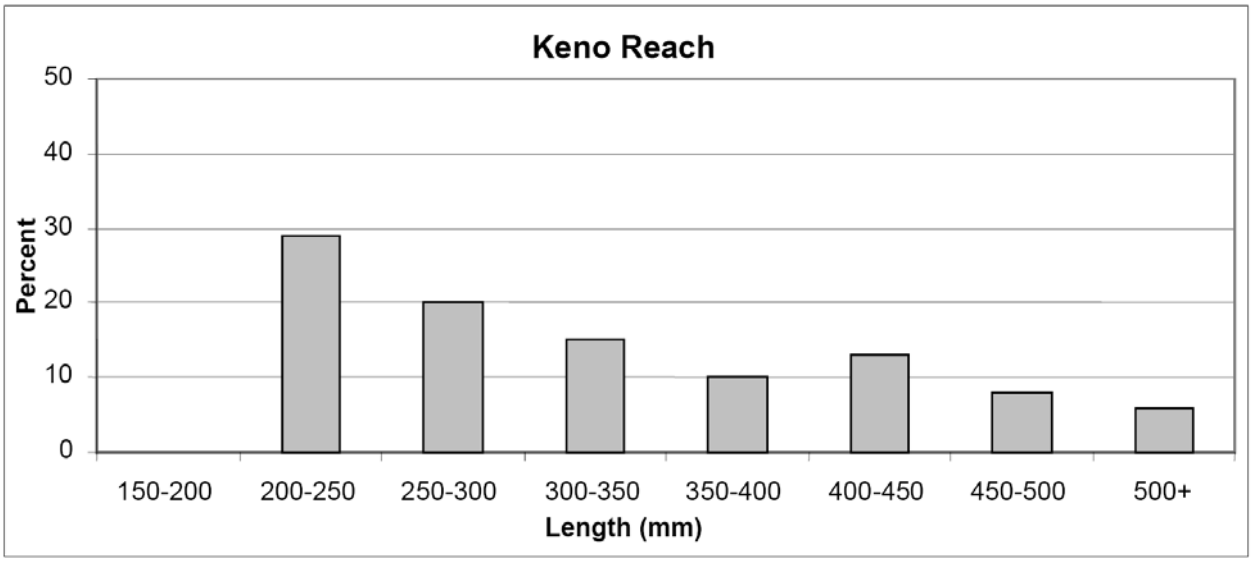
[75]A base flow is the minimum flow that would occur during peaking operations. Although this term has the same meaning as a minimum flow, we use this term because it is more descriptive, and to differentiate from a minimum flow applied to a non-peaking reach.

Table 3-62. Modeled wetted area and rainbow trout WUA modeled for the J.C. Boyle peaking reach. (Source: PacifiCorp, 2005m, as modified by staff)

Simulated Discharge	Average Wetted Area (square feet)	Rainbow Trout WUA (square feet) [*percent of maximum WUA*[a]]		
		Fry	***Juveniles***	***Adults***
320 to 350 cfs (existing minimum)	121,419 *(at 350 cfs)*	4,621 [58]	44,269 [100]	60,993 [97]
420 to 450 cfs (PacifiCorp proposed min)	127,073 (at 450 cfs)	5,076 [64]	44,227 [100]	62,579 [97]
500 cfs (Hoopa Valley proposed min.)	129,317	5,280 [66]	44,031 [99]	62,856 [100]
720 cfs (Oregon Fish & Wildlife, Cal Fish & Game proposed min.)	137,167 *(at 750 cfs)*	5,230 [66]	42,322 [95]	62,144 [99]
1,500 cfs (one unit)	149,597	5,640 [71]	34,299 [77]	54,652 [87]
2,750 cfs (typical 2 unit)	162,400 *(at 2,800 cfs)*	7,766 [98]	24,754 [56]	40,384 [64]

[a] Maximum modeled for fry at 3,000 cfs (7,961 square feet), for juveniles at 400 cfs (44,365 square feet), and for adults at 550 cfs (62,922 square feet).

PacifiCorp also conducted a study to assess the effects of proposed operations on trout growth (Addley et al., 2005). A bioenergetics model was developed that evaluated growth rates based on food availability and ingestion rates compared to energy losses from basic and active metabolism and excretion. A second model was also used that examined food and water temperature effects of growth rates for trout under different flow scenarios. The results of both modeling approaches indicate that food availability is more important than water temperature and physical habitat (WUA) as a factor limiting trout growth in the J.C. Boyle peaking reach. This suggests that current flow fluctuations may account for the smaller size of trout in the peaking reach, as compared with the Keno reach, as a result of decreased benthic macroinvertebrate production (figures 3-89 and 3-90). However, PacifiCorp also reports that the average condition factor (length-weight relationship) of trout larger than 2 inches in the J.C. Boyle peaking reach was 1.20, similar to the 1.18 condition factor of trout in the Keno reach, with condition factors greater that 1.0 for trout considered indicative of healthy fish (Carlander, 1969).



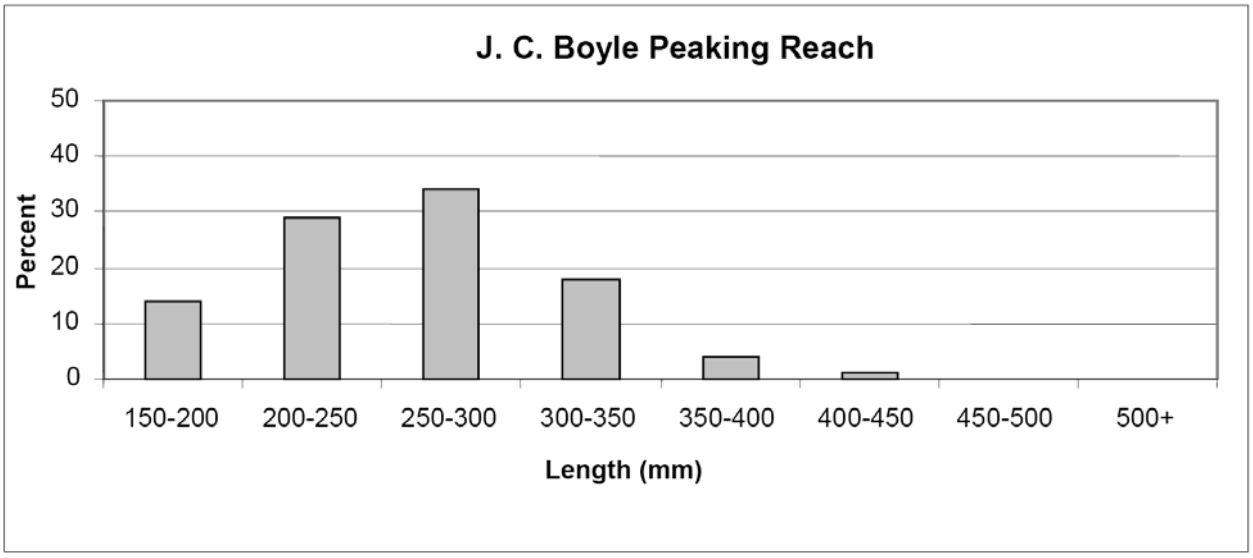


Figure 3-89. Length frequency of sampled trout, from 1979 to 1982 Oregon Fish & Wildlife angler surveys. (Source: PacifiCorp, 2005d)

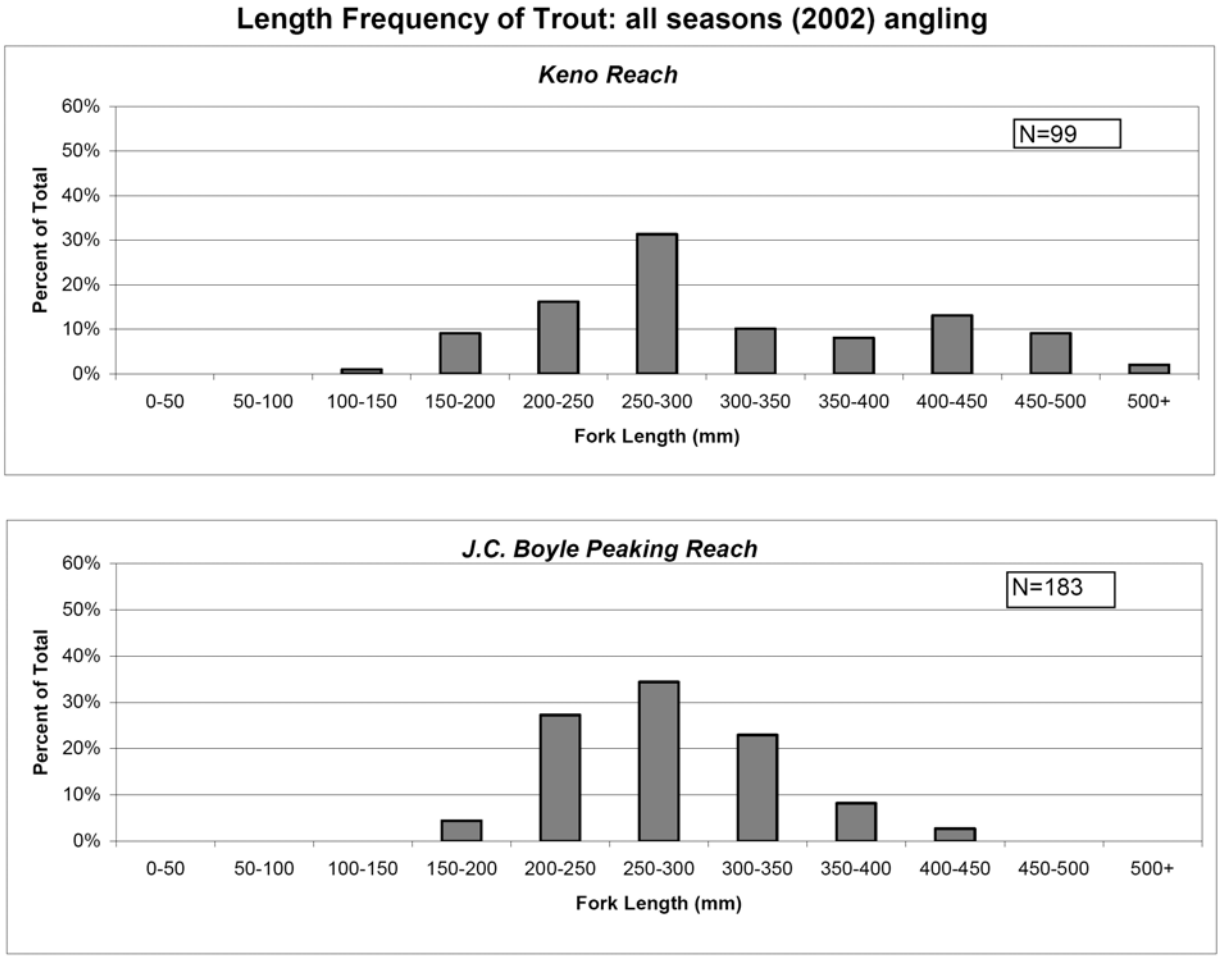


Figure 3-90. Length frequency of trout collected by hook-and-line sampling in 2002. (Source: PacifiCorp, 2005d)

The wetted area versus flow relationships from PacifiCorp's instream flow study indicate that the proposed base flow of 420 to 450 cfs would increase food production by increasing the average wetted area by about 5 percent compared to the current base flow (see table 3-62). Increasing the base flow to the Hoopa Valley Tribe recommended flow of 500 cfs would provide about a 6 percent increase in average wetted area compared to the current base flow, and the Oregon Fish & Wildlife and Cal Fish & Game recommended flow of 720 cfs would provide about an 11 percent increase average wetted area compared to the current base flow. By increasing the area of permanently watered stream channel, these additional increases in base flow would likely increase food production and benefit trout production.

However, available information indicates that the rainbow trout population in this river reach is highly productive, and we expect that this fishery would be sustained and improved under PacifiCorp's proposed flow regime, which would increase base flows and reduce the total range of flow change that would occur under peaking operations. As previously noted, the population of rainbow trout exceeding 7.8 inches was estimated to be 890 fish per mile in the upper 6 miles of the peaking reach and 1,911 fish per mile in the next 5 miles of the river in 1984. These population estimates are comparable to those in the lower Deschutes River in central Oregon, another wild trout stream noted as one of the most productive in the state (National Park Service, 1994). Annual angler catch rates in the Oregon portion of the peaking reach varied from 0.56 to 1.31 rainbow trout per hour during the years 1979 through 1984 and averaged 0.77 rainbow trout per hour. PacifiCorp reported similar catch rates during hook-and-line

sampling conducted in 2004 (see tables 3-60 and 3-61). These catch rates are comparable to or exceed those of other high quality trout streams in Oregon, including the Deschutes and Metolius Rivers (City of Klamath Falls, 1986). Annual angler catch rates in the California portion of the peaking reach were slightly lower, from 0.44 to 0.88 trout per hour during 1974 to 1977, 1981, and 1982, and averaging 0.59 rainbow trout per hour. However, Cal Fish & Game (2000) reported that this reach had the highest overall catch rate among the six wild trout rivers that it monitors in California, and a more recent Cal Fish & Game database indicates that catch rates in the Upper Klamath in 2004 were the highest out of all 33 streams managed under California's Wild and Heritage Trout Program (figure 3-91).

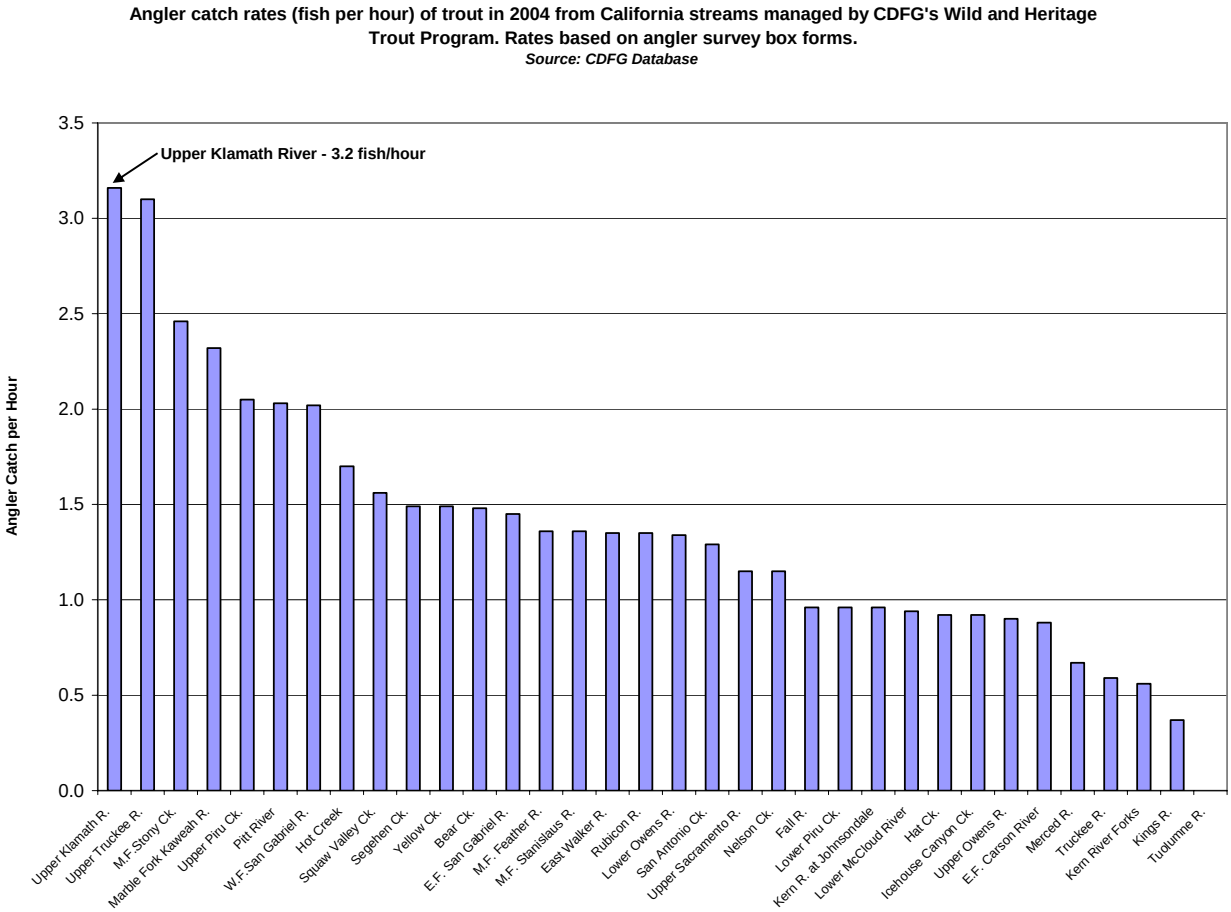
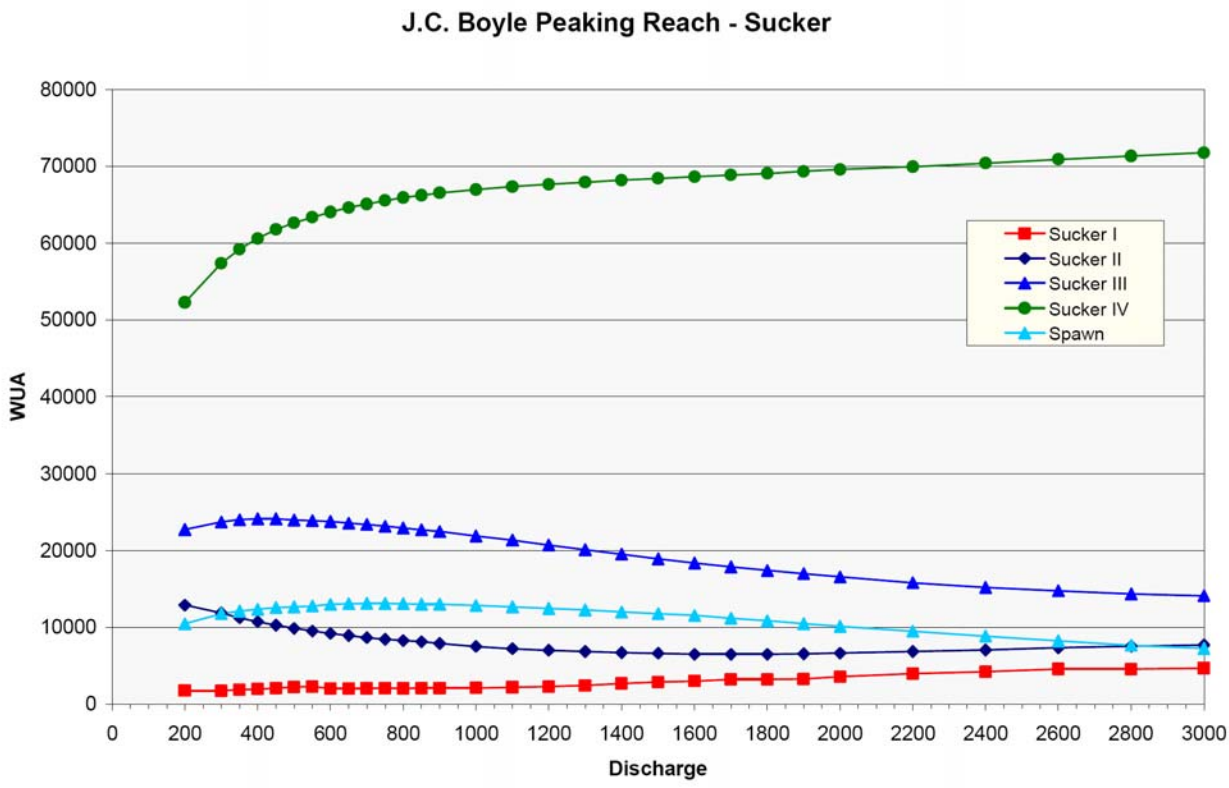


Figure 3-91. Comparison of 2004 angler catch rates among 33 wild trout streams in California. (Source: Exhibit PAC-Ols-D-3 from the EPAct 2005 proceeding on mandatory conditions for the Klamath Hydroelectric Project)

PacifiCorp reports that some Lost River suckers from Copco reservoir have been observed moving into the lower end of the J.C. Boyle peaking reach, and some spawning may occur in the first riffle upstream of Copco reservoir. PacifiCorp's instream flow modeling results for sucker species indicate that their proposed minimum flow of 420 to 450 cfs would maximize spawning habitat for suckers, and would increase the amount of rearing habitat for most rearing life stages (figure 3-92). Implementing run-of-river operations would provide more stable habitat conditions, which could provide some benefit to suckers that spawn in this reach. However, Desjardins and Markle (2000) conclude that predation rates on larval suckers entering Copco reservoir are likely very high due to the abundance of introduced warmwater species in the reservoir. This suggests that the population of Lost River and

shortnose suckers Copco reservoir is supported primarily by the downstream movement of juvenile and adult suckers from Upper Klamath Lake and J.C. Boyle reservoir. Accordingly, it appears unlikely that implementing run-of-river operations would provide a discernable benefit to the populations of Lost River and shortnose suckers in Copco reservoir.



Note: WUA is shown for the following sucker life stages: (I) non-demersal (bottom dwelling) larvae <26 mm; (II) young-of-year suckers 26-75 mm; (III) juveniles 75-150 mm; and (IV) adults >150 mm.

Figure 3-92. Sucker WUA versus discharge for the J.C. Boyle peaking reach. (Source: PacifiCorp, 2005m)

Flow fluctuations in the J.C. Boyle peaking reach have the potential to cause fish stranding, especially for smaller fish that favor shallow-water habitats. During stranding surveys conducted at 10 study sites in the peaking reach, PacifiCorp found a total of four sculpin, one dace, and one unidentified sucker that were stranded, and 8 to 10 trout fry that were trapped in a pothole (table 3-63). Although few trout fry were observed along the stream margins during the surveys, the lack of stranded trout, observed by PacifiCorp, suggests that the stranding potential for trout fry in this reach may be low at the current ramping rate.

Table 3-63. Peaking reach fish stranding and entrapment observations, 2002. (Source: PacifiCorp, 2005d)

Site	Δ Flow	Number Stranded	Number Trapped	Notes
		May 31, 2002		
Island Complex	1,500 – 350	0	0	
Miller Bridge	1,500 – 350	0	0	
Foam Eddy	1,500 – 350	0	0	
Caldera	1,500 – 350	0	0	
Point BAR	1,500 – 350	0	0	
		July 11, 2002		
Island Complex	1,500 – 350	0	0	Numerous dace along margins.
Miller Bridge	1,500 – 350	0	0	Several trout fry in side channel. Numerous dace at Shovel Creek mouth.
Foam Eddy	1,500 – 350	0	8-10 trout fry	Trapped fry in 10 foot x 3 foot pothole. Several trout fry observed along river margin.
Caldera	1,500 – 350	0	0	100s of dace along river margin.
Point BAR	1,500 – 350	0	0	Numerous dace in river above Shovel Creek.
		August 8-9, 2002		
Island Complex	1,500 – 350	0	0	Hundreds of 1-inch to 1.5-inch dace along margins. Several trout fry along margin.
Miller Bridge	1,500 – 350	0	0	Several trout fry in side channel.
Foam Eddy	1,500 – 350	0	0	
Caldera	1,500 – 350	0	0	
Point BAR	1,500 – 350	0	0	

Dunsmoor (2006) conducted a series of surveys in the J.C. Boyle peaking reach to assess stranding rates during the first several peaking cycles that occurred in 2006. He conducted surveys at Frain Ranch in the Oregon section on July 4, 5, 7, and 8, and below Shovel Creek in the California section on July 6. His survey during the first peaking cycle at Frain Ranch found large numbers of stranded juvenile sculpin, smaller numbers of juvenile and larval suckers and minnows, and many dead aquatic insects and crayfish. No dead fish were found at Frain Ranch during the surveys on July 7 and 8, and the number of dead crayfish and insects was lower in the second and third surveys. Based on transect sampling conducted on July 7, Dunsmoor estimated that the density of stranded crayfish was 0.37 per square foot on that date. Although he did not conduct a similar quantitative sampling effort on July 4 and 5, his report includes photographs that document substantial numbers of dead larval and juvenile fish, crayfish, and insects that were stranded at the Frain Ranch site during the first peaking cycle. His survey of the Shovel Creek site on July 6 did not reveal any dead fish, although thousands of live larval and juvenile fish were entrapped in a large pool that was isolated from the river at the time of the survey. Dunsmoor attributes the lower stranding rate observed below Shovel Creek to slower rates of water level changes from attenuation in the lower part of the peaking reach.

In most areas of the J.C. Boyle peaking reach, the toe-of-bank, which defines the edge of the predominant active stream bed, occurs at the water's edge at flows of about 1,000 cfs. As a result, flow reductions below 1,000 cfs have a higher stranding potential than reductions from higher flows, because the area dewatered for a given change in stage increases. Accordingly, PacifiCorp's proposed reduction in the downramp rate to 4 inches per hour when flows at the gage are less than 1,000 cfs would reduce the risk of fish stranding compared to the existing ramp rate of 9 inches per hour. The 4 inches per hour ramp

rate would attenuate to about 3 inches per hour at Frain Ranch (RM 214.3) and to about 2 inches per hour near Shovel Creek (RM 201.5), further reducing the stranding potential in downstream areas.

The Bureau of Land Management's specified 2 inch per hour ramping rate, and Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe's recommendation of a 1 inch per hour ramping rate may reduce the stranding potential even further. Based on the stranding observations made by Dunsmoor in 2006, it is likely that this more gradual ramping rate would reduce stranding of fish, crayfish, and invertebrates, especially during the first several peaking cycles that occur after a period of relatively stable flows. Reduced stranding of these species would likely improve the forage base available to redband trout, which would improve their growth and survival in the peaking reach. A similar benefit would be provided by run-of-river operation. Bureau of Land Management's specified release of 1,500 to 3,000 cfs 1 day a week would not benefit the aquatic resources in the peaking reach, but would provide flows for whitewater boating.

An alternative to implementing a restrictive ramping rate year-round, which would have a substantial effect on the ability of the project to meet peaks in electrical demand, would be to implement a graduated ramping rate for the first several cycles after peaking operation commences. For example, ramping at a rate of 2 inches per hour in the first day of peaking, 4 inches per hour in the second day of peaking, and 6 inches per hour in the third day of peaking, would provide fish and invertebrates more time to acclimate to the change in operations, which may reduce the overall rate of stranding mortality. The effectiveness of this type of graduated ramping for reducing stranding could be evaluated via monitoring and adjusted based on monitoring results.

Copco No. 1 and 2

Copco No. 1 powerhouse has a maximum hydraulic capacity of 3,200 cfs. The powerhouse is operated as a peaking facility, discharging directly into the Copco No. 2 forebay. Because discharges occur directly into the Copco No. 2 forebay, there is no riverine habitat directly affected by Copco No. 1 peaking operations. Copco No. 2 powerhouse is a peaking facility that operates synchronously with Copco No. 1. The powerhouse, located about 1.5 miles downstream of the Copco No. 2 diversion dam, discharges into Iron Gate reservoir. Consequently, there is no riverine habitat affected by Copco No. 2 peaking operations. Currently there are no ramp rate or minimum flow restrictions for the 1.5-mile-long bypassed reach between Copco No. 2 dam and Copco No. 2 powerhouse. Ramping of flows in the bypassed reach is infrequent and occurs only when maintenance requires spill at the dam, during a forced outage, or when inflows are greater than the hydraulic capacity of the powerhouse.

Currently, PacifiCorp voluntarily provides about 10 cfs of flow into the Copco No. 2 bypassed reach via leakage of the spill gates and from a small sluiceway. PacifiCorp proposes to maintain a minimum flow of 10 cfs in the Copco No. 2 bypassed reach, and to make improvements to the Copco No. 2 bypass flow gate so that the 10 cfs would be regulated through an automated gate that allows for changes in water surface elevation in the Copco No. 2 reservoir. They also propose to limit flow downramp rates to 125 cfs per hour (equivalent to less than 2 inches per hour) in the Copco No. 2 bypassed reach, except for flow conditions beyond the project's control.

Oregon Fish & Wildlife, Cal Fish & Game, NMFS and FWS all recommend that PacifiCorp release a minimum instantaneous minimum flow of 730 cfs or 40 percent of the inflow, whichever is greater. Inflow would be computed as a 3-day running average of flows at the J.C. Boyle powerhouse gage added to the flow from Shovel Creek, as measured by a new gage. The Hoopa Valley Tribe recommends that PacifiCorp discharge a continuous minimum flow of 500 cfs or 70 percent of inflow to the project, whichever is greater, or total project inflow when the inflow is less than 500 cfs. However, in its alternative section 18 prescription, Hoopa Valley Tribe recommends the same flow regime as Oregon Fish & Wildlife, Cal Fish & Game, NMFS, and FWS.

Our Analysis

Fish sampling performed in the Copco No. 2 bypassed reach in 2001 and 2002 indicates that speckled dace and marbled sculpin are the most abundant fish in the reach, with much smaller numbers of rainbow trout, chubs, largemouth bass, crappie, and yellow perch. With the exception of speckled dace and marbled sculpin, most of the fish in the reach likely originate from downstream movement of fish out of Copco reservoir or from upstream movement of fish out of Iron Gate reservoir.

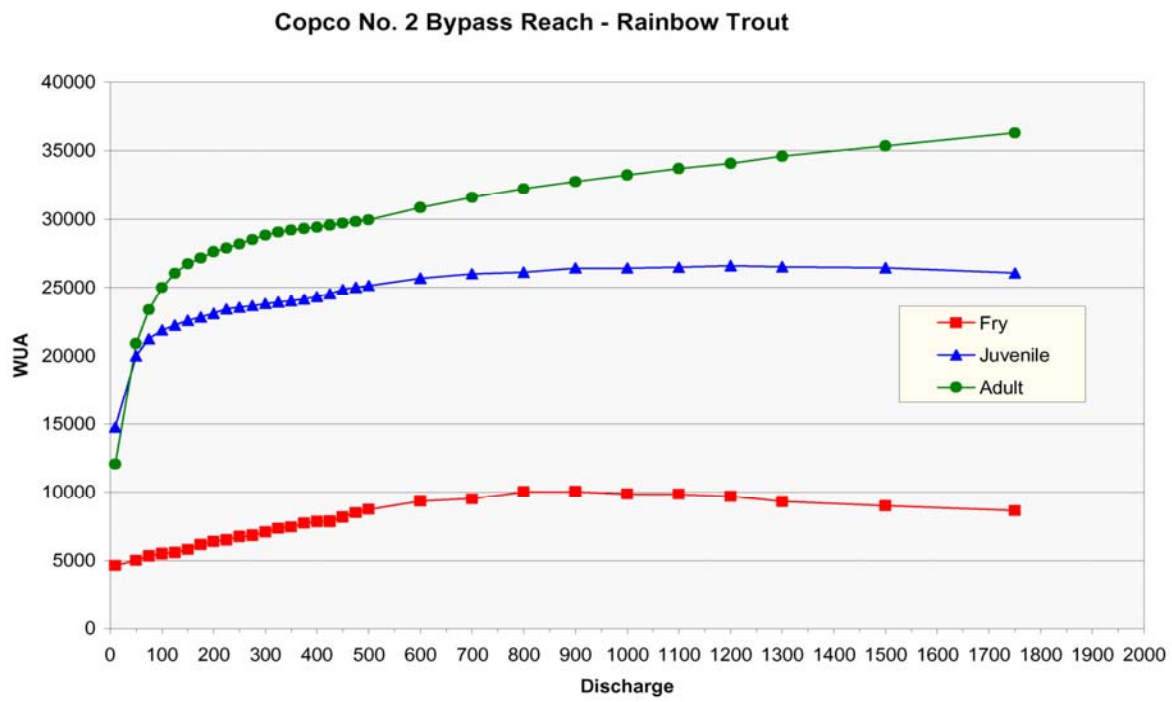
The 10 cfs flow that PacifiCorp voluntarily releases and proposes as a minimum flow provides limited habitat for fish and other aquatic biota, with water temperatures in this reach during the summer favoring warmwater species. Although fish use of this reach is limited, the occasional downramping that occurs when Copco No. 1 is coming off spill and during other maintenance events has the potential to cause stranding of small fish.

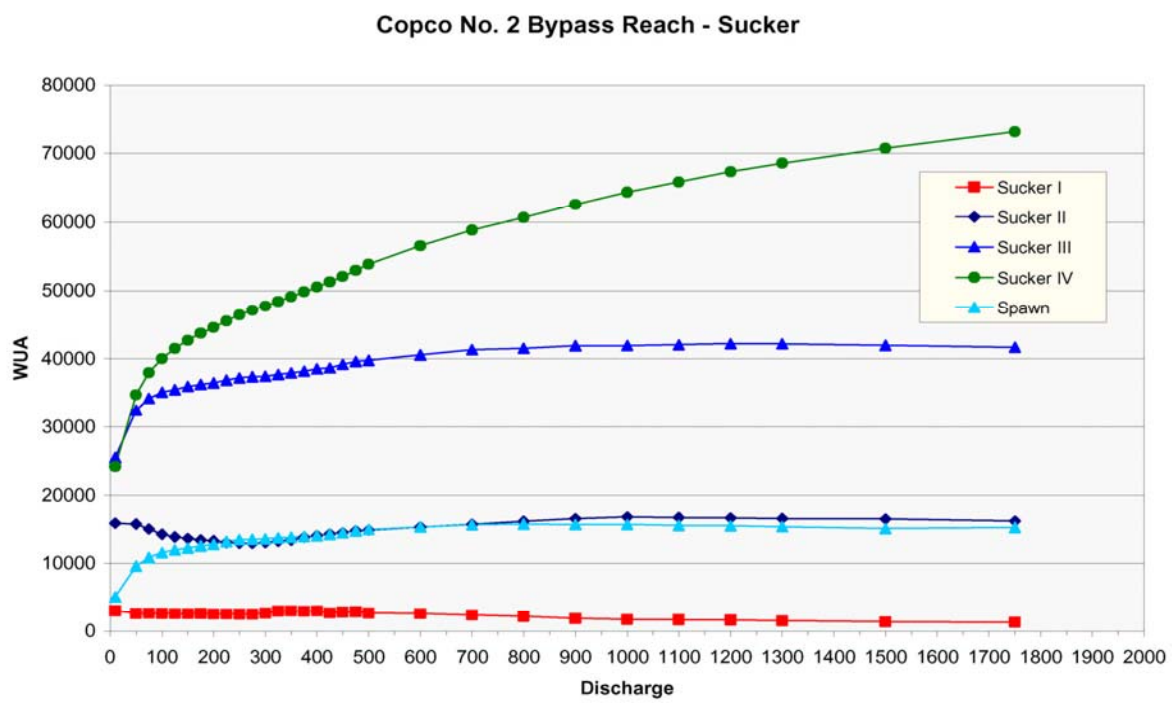
An instream flow study conducted by PacifiCorp in the Copco No. 2 bypassed reach indicates that there is little instream habitat (WUA) for the adult and juvenile life stages of rainbow trout and suckers at the current minimum flow of 10 cfs (figure 3-93). Modeling results indicate that available habitat for juvenile and adult trout increases rapidly at flows of up to 75 to 100 cfs. Habitat at 10 cfs is only 55 and 33 percent of maximum WUA for juvenile and adult trout, but increases to 80 and 63 percent of maximum WUA, respectively, at flows of 75 cfs (table 3-64). Habitat for trout fry increases very gradually, from 46 percent of maximum at 10 cfs to 53 percent, 67 percent, 87 percent, and 95 percent of maximum WUA at flows of 75, 250, 500, and 730 cfs, respectively. Although flows in excess of 500 cfs increase the available habitat for trout, other physical constraints such as water quality conditions, especially water temperature, would continue to be a limiting factor for trout productivity in the reach. Although rainbow trout in the Klamath River are able to tolerate higher water temperatures than most other salmonids, we expect that the species composition would continue to be dominated by the warmwater fish species that are most prevalent in Copco and Iron Gate reservoirs.

Table 3-64. Estimates of wetted perimeter and rainbow trout WUA habitat modeled for the Copco No. 2 bypassed reach. (Source: PacifiCorp, 2005m, as modified by staff)

Simulated Discharge	**Average Wetted Area (square feet)**	**Rainbow Trout WUA (square feet) [percent of maximum WUA[a]]**		
		Fry	***Juveniles***	***Adults***
10 cfs (existing minimum – PacifiCorp proposed)	54,695	4,634 [46]	14,757 [55]	12,058 [33]
75 cfs	58,601	5,323 [53]	21,234 [80]	23,356 [63]
250 cfs	70,146	6,749 [67]	23,543 [89]	28,184 [78]
500 cfs (Hoopa Valley Tribe recommended)	87,157	8,722 [87]	25,143 [95]	29,952 [83]
730 cfs (Oregon Fish & Wildlife, Cal Fish & Game, NMFS, FWS recommended)	92,399 *(at 700 cfs)*	9,509 [95]	26,026 [98]	31,591 [87]

[a] Maximum modeled for fry at 900 cfs (10,028 square feet), for juveniles at 1,200 cfs (26,602 square feet), and for adults at 1,750 cfs (36,290 square feet).





Note: WUA is shown for the following sucker life stages: (I) non-demersal (bottom dwelling) larvae <26 mm; (II) young-of-year suckers 26-75 mm; (III) juveniles 75-150 mm; and (IV) adults >150 mm.

Figure 3-93. WUA for rainbow trout and suckers in the Copco No. 2 bypassed reach. (Source: PacifiCorp, 2005m)

The results of the instream flow study indicate that habitat for most life stages of suckers, and spawning habitat, would increase substantially if flows were increased to 70 to 100 cfs, while the rate of habitat increase tapers off at higher flows (see figure 3-93). However, we find no evidence in the record to indicate that the federally listed shortnose or Lost River suckers spawn in the Copco No. 2 bypassed reach. Although Desjardin and Markle (2000) did capture larval suckers in Iron Gate reservoir, their abundance declined rapidly over the rearing season and no juvenile suckers were collected, suggesting that predation limits recruitment and that adult suckers found in Iron Gate reservoir were probably recruited as juvenile or adult migrants from Upper Klamath Lake or from J.C. Boyle reservoir. Accordingly, we conclude that any benefits to shortnose or Lost River suckers from increased flows in the Copco No. 2 bypassed reach would be negligible.

Prior to construction of Iron Gate dam, the reach from the Iron Gate dam site to Copco No. 1 dam did support spawning by fall Chinook salmon (Coots and Wales, 1952). An estimated 300 Chinook salmon spawned in the reach in 1952, and the observed flow during their survey was estimated at 8 cfs. Unlike rainbow trout, fall Chinook salmon outmigrate after rearing in freshwater for several months, so if this species is introduced to the Copco No. 2 bypassed reach, it may emigrate from the reach before water temperatures become severely stressful in July and August. With gravel augmentation and implementation of a higher minimum flow, we expect that the Copco No. 2 bypassed reach could support a larger number of Chinook salmon spawners than could by supported without such enhancements, although the ability to develop a self-sustaining run would depend on successful passage through Iron Gate reservoir, past Iron Gate dam, and through the lower Klamath River.

Copco No. 2 Seasonal High Flows

Oregon Fish & Wildlife recommend that, at least once a year between February 1 and April 15 when inflow to J.C. Boyle reservoir (including Spencer Creek) exceeds 3,300 cfs, PacifiCorp not divert water to the J.C. Boyle or Copco No. 2 power canals for at least 7 full days. The downramp rate for the seasonal high flow would not exceed 2 inches per hour and 300 cfs per 24-hour period, as measured at the new gage to be installed downstream of Boyle dam. FWS makes a similar recommendation, but specifies that diversion to the Copco No. 2 powerhouse would stop when inflow to Copco reservoir exceeds 3,300 cfs, as measured from the new gage below J.C. Boyle dam at RM 225 and a new gage to be installed at Shovel Creek, combined. The downramp rate would not exceed 300 cfs per 24 hours, measured at a new gage to be installed below the Copco No. 2 powerhouse.[76]

Our Analysis

Provision of an annual seasonal high flow event as recommended by the agencies could help to ensure that spawning gravel areas used by trout remain sufficiently free of silt to support egg incubation and trout recruitment. Our review of the average spill duration and quantity information presented in table 3-19 indicates that spillage to the Copco No. 2 bypassed reach is sufficient to flush fine-grained sediment in many years. The hydraulic capacity of the Copco No. 1 powerhouse is 2,360 cfs. When inflow to Copco reservoir exceeds the hydraulic capacity of the powerhouse, spillage would typically occur. A reasonable estimate of inflow to Copco No. 2 reservoir under average conditions can be obtained by adding the average spill flow at Copco No. 1 to the hydraulic capacity of Copco No. 1 powerhouse. Based on information in table 3-19, inflow to Copco No. 2 reservoir during spill events at Copco No. 1 dam ranged from 6,042 cfs in January to 4,391 cfs in May. The hydraulic capacity of the

[76]Two of the stated FWS gage locations appear to be typographical errors, since a gage located at RM 225 would only measure flow in the J.C. Boyle bypassed reach (unlike the existing USGS gage downstream of the J.C. Boyle powerhouse) and a gage downstream of the Copco No. 2 powerhouse would be in Iron Gate reservoir, and could not be used as a compliance point for a downramping rate in the Copco No. 2 bypassed reach.

Copco No. 2 powerhouse is 2,676 cfs, which means that spillage to the Copco No. 2 bypassed reach under average conditions would range from about 3,366 cfs in January to about 1,715 cfs in May. Such flows should be sufficient to mobilize fine-grained sediment that may be embedded in spawning gravel in the Copco No. 2 bypassed reach. We expect the duration of average spill events at Copco No. 2 dam to be similar to that shown for Copco No. 1 dam (up to about 8 days). These spill characterizations represent average conditions from 1990 to 2004, so during some years, there would have been spills of longer duration and higher flows, whereas during other years, there could be little if any spill at Copco No. 1 and No. 2 dams.

Prior to construction of Iron Gate dam, this reach did support spawning by fall Chinook salmon (Coots and Wales, 1952). If access to this reach is restored for anadromous fish, spawning habitat for anadromous species could be enhanced by sediment augmentation. If such a program were to be implemented, we conclude that there would likely be sufficient seasonal high flow events to maintain the suitability of gravel for spawning, but monitoring of spawning habitat would serve to confirm our prediction and provide a basis for supplemental sediment augmentation, if high flow events transport gravel through the bypassed reach.

Copco No. 2 Ramp Rates

PacifiCorp proposes to limit downramping to 125 cfs per hour. Ramping flows through the Copco No. 2 bypassed reach would be accomplished by regulating flows at the Copco No. 1 development, except that flows less than 3,200 cfs would be controlled at the Copco No. 2 dam. To the extent possible, flow changes would occur during the night to reduce the potential for fish stranding.

The Oregon Fish & Wildlife, Cal Fish & Game and Forest Service recommend that ramp rates at Copco No. 2 dam not exceed 1 inch per hour at any time, and not exceed 300 cfs in any one 24-hour period. These ramp rates would apply to all hydro-controlled operations including load following, re-regulating, project start-up, and planned shutdowns. Cal Fish & Game also recommends that PacifiCorp operate the J.C. Boyle, Copco No. 1 and Copco No. 2 developments as run-of-river facilities in conjunction with meeting minimum target flows. As previously described, the Hoopa Valley Tribe recommends a ramping rate that ranges from 1.2 to 2.4 inches per hour.

Our Analysis

Fish use of the Copco No. 2 bypassed reach is limited, most likely due to low flows and high water temperatures during the summer months. Downramping in this reach is rare and occurs primarily when Copco No.1 is coming off of a spill event or during scheduled maintenance shutdown of the Copco No. 2 powerhouse. Such events may strand some fish in the bypassed reach.

The PacifiCorp proposed ramp rate of 125 cfs per hour is equivalent to less than 2 inches per hour in most flow ranges. In addition, the proposal to downramp at night would further minimize the potential for fish stranding, especially during the winter when small trout, and perhaps other species, tend to be less closely associated with the bottom substrate than during the day. A ramp rate of 1 inch per hour as proposed by Oregon Fish & Wildlife, Cal Fish & Game, and the Forest Service would also be protective of smaller fish and reduce the incidence of stranding, but may be more restrictive than is needed to protect fish in the reach, given the limited nature of the fishery and the infrequent need for ramping.

Fall Creek

Fall Creek, which originates from headwater spring sources, has an extremely stable flow regime. Flows routed to the Fall Creek powerhouse run almost continuously, passing either through the turbines or the flow-continuation valve. Cal Fish & Game operates a salmon rearing facility at Fall Creek downstream of the powerhouse that requires continuous flow. Although there is no prescribed downramp rate for the diversion dam, the need to reduce flows is rare, only occurring when canal maintenance is

required. The rate at which flow is returned to the canal affects the rate at which flows decrease in the bypassed reach. Fish stranding has not been documented during these maintenance activities.

The diversion dam on Fall Creek diverts up to 50 cfs of flow that bypasses 1.2 miles of a very steep gradient section of Fall Creek leading to the Fall Creek powerhouse. The project's current license requires a minimum flow of 0.5 cfs below the Fall Creek diversion and a minimum flow of 15 cfs (or natural stream flow, whichever is less) downstream of the powerhouse. Roughly 99 percent of the streamflow is diverted except during infrequent and brief storm events when flows exceed 50 cfs.

PacifiCorp proposes to increase the minimum flow release to 5 cfs into the Fall Creek bypassed reach, and to continue to maintain a minimum flow of 15 cfs downstream of the bypass confluence with the powerhouse tailrace. Flow release control structures associated with the proposed fish passage facilities (discussed later in section 3.3.3.2.2, *Fish Passage*), at the dam would be constructed to maintain the continuous 5 cfs release at the dam.

Cal Fish & Game, Oregon Fish & Wildlife, and FWS recommend that a minimum of 40 percent of the instantaneous flow measured above the Fall Creek power canal diversion be released into the Fall Creek bypassed reach, which when applied to historic USGS data (gage no. 1151200 on Fall Creek just above Iron Gate reservoir), would provide a minimum flow between 14 and 22 cfs (letter from Interior dated March 27, 2006). Cal Fish & Game, Oregon Fish & Wildlife, and FWS also recommend installing new gages above and below the diversion dam.

Oregon Fish & Wildlife, Cal Fish & Game and FWS recommend that ramp rates at Fall Creek diversion not exceed 1 inch per hour any time day or night, and not exceed 300 cfs in any 24 hour period. The ramp rates would apply to all hydro-controlled operations including load following, re-regulating, project start-up, and planned shutdowns.

Our Analysis

The Fall Creek bypassed reach supports a population of rainbow trout, nearly all of which are smaller than 6 inches. Results of fish sampling conducted by PacifiCorp in July 2005 in Fall Creek (PacifiCorp, 2005a) found only one trout (4 to 6 inches) in the power canal. Fifteen trout were caught in the bypassed reach, ranging in size from 2 to 8 inches, with an average size of 4 inches. Above the diversion, 9 trout were collected, ranging in size from 2 to 6 inches, with an average size of 4.5 inches (PacifiCorp, 2005a). PacifiCorp reported that the catch per unit effort between the Fall Creek bypassed reach and above the Fall Creek diversion exhibited a fairly wide range (81.8 to 187.5 fish per hour), however, the catch per 100 feet of stream was less variable, at 3.1 and 3.6 fish per hour, respectively. These results indicate that the trout populations in the two reaches are similar, despite the difference in flows.

PacifiCorp's instream flow analysis indicates that its proposed 5 cfs minimum flow would increase the available habitat in the bypassed reach by about 16 percent for fry, 32 percent for trout juveniles (less than 6 inches), and 28 percent for adult trout (figure 3-94, table 3-65). Increasing minimum flows to 14 cfs as recommended by Cal Fish & Game, Oregon Fish & Wildlife, and FWS would increase the available habitat over current conditions by about 21 percent for trout fry, about 52 percent for juveniles, and 66 percent for adults. Increasing available habitat would potentially result in an increase in populations in the bypassed reach. However, given the similarity of trout populations upstream and downstream of the diversion, the higher flows recommended by Cal Fish & Game, Oregon Fish & Wildlife, and FWS probably would provide only a limited benefit to the fishery compared to PacifiCorp's proposed 5-cfs minimum flow.

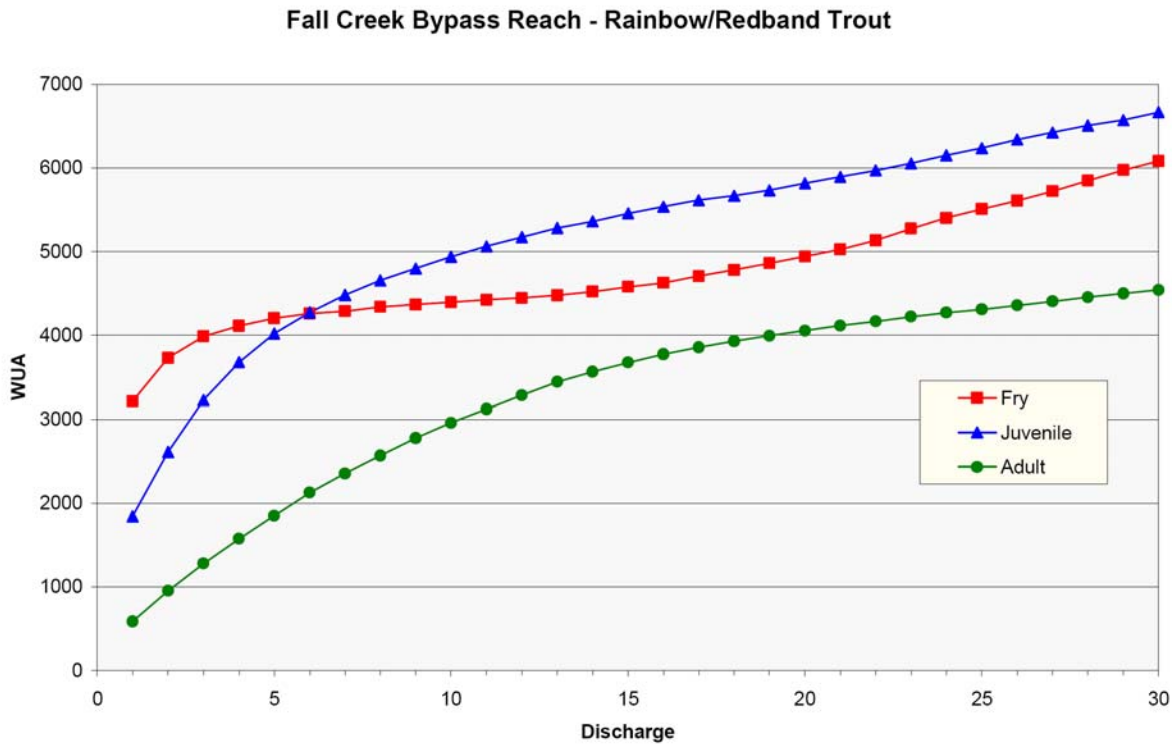


Figure 3-94. WUA versus discharge for rainbow trout in Fall Creek. (Source: PacifiCorp, 2005m)

Table 3-65. Estimates of wetted perimeter and rainbow trout WUA modeled for the Fall Creek bypassed reach. (Source: PacifiCorp, 2005m, as modified by staff)

Discharge	Average wetted perimeter (ft)	Rainbow Trout WUA (ft) [*percent of maximum WUA*[b]] *Fry*	*Juveniles*	*Adults*
0.5 cfs (existing min)	11,747 (at 1 cfs)	3,214 [53]	1,843 [28]	586 [13]
5 cfs (PacifiCorp proposed)	13,795	4,204 [69]	4,022 [60]	1,851 [41]
14 cfs[a]	15,813	4,523 [74]	5,362 [80]	3,565 [79]
22 cfs[a]	18,370	5,135 [84]	5,971 [90]	4,166 [92]

[a] Cal Fish & Game, Oregon Fish & Wildlife, and FWS minimum flow of 40 percent of inflows would likely be between 14 and 22 cfs.

[b] Maximum modeled WUA for all life stages occurred at 30 cfs - 60,882 square feet for fry, 6,667 square feet for juveniles, and 4,540 square feet for adults. Maximum flow modeled was 30 cfs.

PacifiCorp's proposed 15 cfs minimum flow for the stream reach downstream of the tailrace confluence with the bypass channel is the same as the current license requirement. This flow-related measure is largely moot because of the powerhouse flow continuation valves, which maintain flow in lower Fall Creek even if the powerhouse is not operating. The minimum flow would only pertain to rare occasions when the powerhouse or diversion canal is in the process of being shut down and flow is being

returned to the bypass channel. This process must be done slowly enough to allow the required 15 cfs to reach the lower creek before the canal diversion is completely shut off.

The Oregon Fish & Wildlife, Cal Fish & Game, and FWS recommendation to limit the ramping rate at Fall Creek to 1 inch per hour and 300 cfs per 24 hours would be protective of fish resources. Given that ramping is infrequent and ramp rates are limited by the requirement to maintain a minimum flow of 15 cfs downstream, however, a 1 inch per hour ramp rate would provide little additional benefit.

Spring Creek

PacifiCorp maintains an earthen dam on Spring Creek, and has a water right for 16.5 cfs. The Spring Creek diversion is located 0.5 mile upstream from its confluence with Jenny Creek, and the diverted flow is carried through a 1.7-mile-long canal where it enters Fall Creek about 1.7 miles upstream of the Fall Creek power canal diversion. There are several unnamed springs that are captured in the Spring Creek canal. The Spring Creek diversion directs up to 16.5 cfs of flow into Fall Creek, and the Fall Creek diversion diverts up to 50 cfs into the power canal that leads to the Fall Creek powerhouse. In the summer, when flow from Spring Creek is diverted to Fall Creek, only about 0.22 cfs is returned to Spring Creek, and the downstream third of the creek is dewatered (letter from Interior, March 27, 2006).

PacifiCorp proposes to shut the Spring Creek diversion dam canal headgate so that no flow is diverted during July and August. For the remainder of the year they propose to position the slide gate to release 1 cfs of flow into the bypassed reach, if available.

In their response to the REA notice, Oregon Fish & Wildlife, Cal Fish & Game, and FWS recommended that no flow diversion occur from June 1 through September 15, and that 50 percent of inflows be released to the reach downstream of the diversion dam during the remainder of the year. In their comments on the draft EIS, all three agencies modified their flow recommendations to 4 cfs for the period from September 16 to May 30. Oregon Fish & Wildlife, Cal Fish & Game, and FWS also recommend that ramp rates at Spring Creek diversion not exceed 1 inch per hour at any time, and not exceed 300 cfs in any 24-hour period. The ramp rates would apply to all hydro-controlled operations including load following, re-regulating, project start-up, and planned shutdowns.

Our Analysis

The Jenny Creek watershed supports several native fish species including the Jenny Creek sucker, rainbow trout, and Klamath speckled dace. Sampling conducted in Spring Creek resulted in the collection of 16 rainbow trout upstream of the diversion dam, 1 rainbow trout downstream of the diversion dam, and 6 trout in the diversion canal (PacifiCorp, 2005a). Closing off the Spring Creek diversion in the summer months would alleviate dewatering of the Spring Creek bypassed reach, and facilitate cooling in Jenny Creek by allowing the much colder water from Spring Creek to flow into Jenny Creek. However, there are two non-project diversions on Spring Creek, so the amount of water from Spring Creek that actually flows into Jenny Creek is unknown.

Comparing data collected by the Bureau of Land Management in Jenny Creek above and below the Spring Creek confluence in 1995, 1996, and 1997 shows that inflows from Spring Creek reduce water temperatures in lower Jenny Creek. Average temperature difference from June through September was 0.5, 0.8, and 1.1°C for 1995, 1996, and 1997, respectively (figures 3-95 through 3-97) (PacifiCorp, 2004i). In 1995 and 1996, the cooling effect was most pronounced in July and August, but in 1997 the cooling effect extended from June through mid-September. Shutting down PacifiCorp's Spring Creek diversion from June 1 to September 15, as agencies recommend, would improve summer water temperatures for trout rearing in Jenny Creek, especially in hot and dry years.

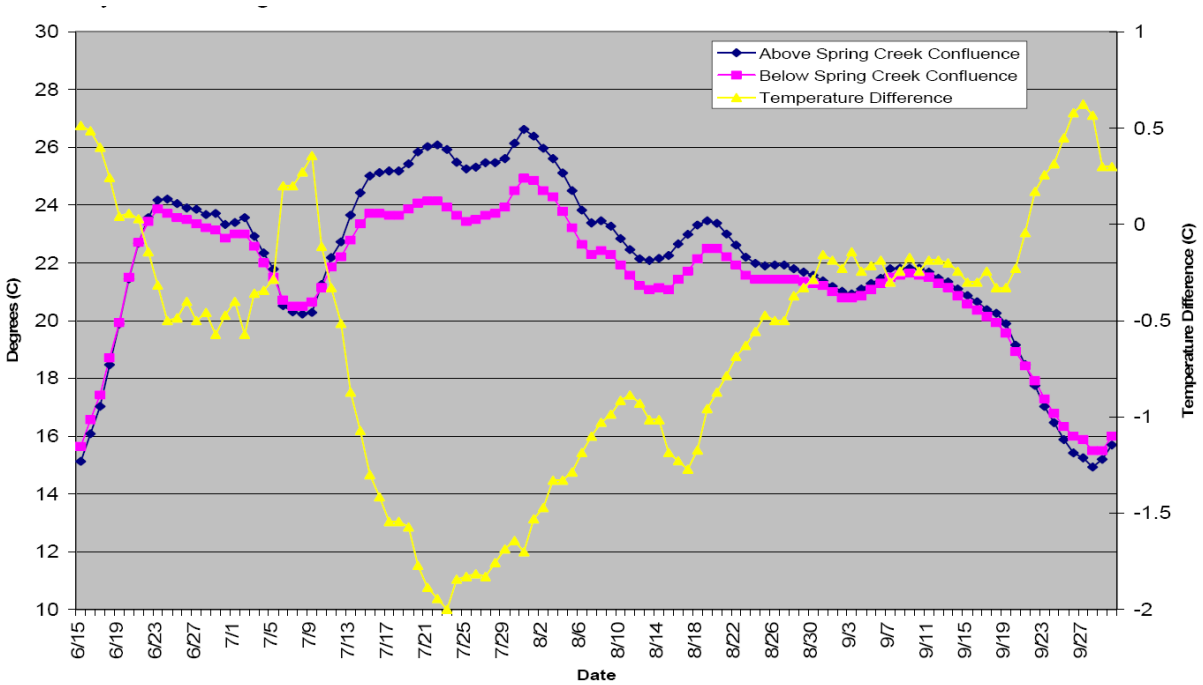


Figure 3-95. Seven-day moving average water temperatures from 1995 recorded in Jenny Creek above and below the confluence with Spring Creek. (Source: PacifiCorp, 2004i)

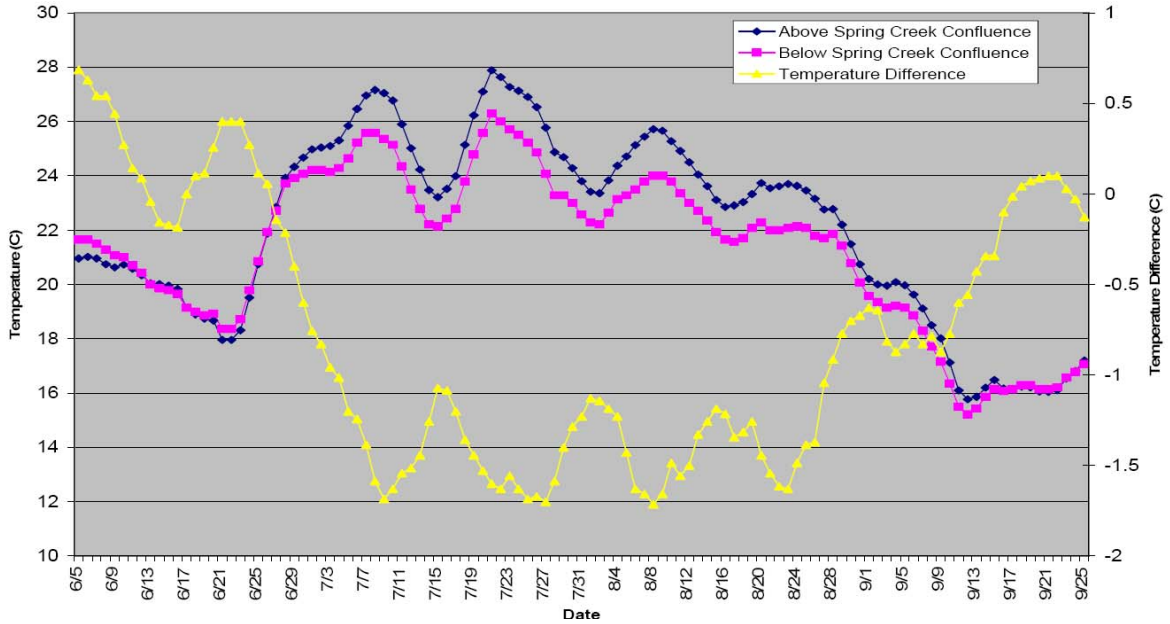


Figure 3-96. Seven-day moving average water temperatures from 1996 recorded in Jenny Creek above and below the confluence with Spring Creek. (Source: PacifiCorp, 2004i)

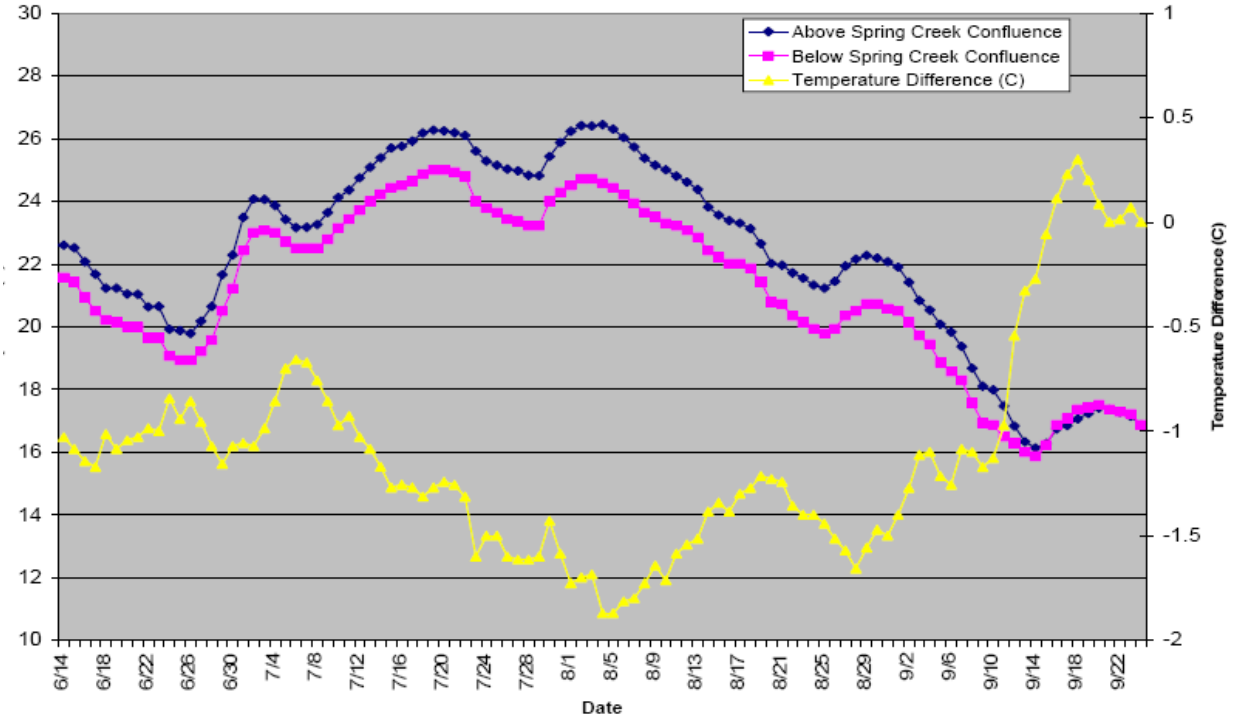


Figure 3-97. Seven-day moving average water temperatures from 1997 recorded in Jenny Creek above and below the confluence with Spring Creek. (Source: PacifiCorp, 2004i)

PacifiCorp's proposal of releasing a 1 cfs minimum flow (or inflow, if inflow is less than 1 cfs) at all other times would help to prevent dewatering in Spring Creek and help to maintain some aquatic habitat downstream of the diversion, although as stated above there are other diversions on Spring Creek that are beyond PacifiCorp's control. The Oregon Fish & Wildlife, Cal Fish & Game, and FWS recommendation that 50 percent of the flow above the diversion be released to the reach downstream of the diversion dam from September 16 through May 31 regardless of flow volume would likely increase available habitat over current conditions; however, due to a lack of data we are unable to quantify the extent of such benefit. Releasing 50 percent of the inflow would require some type of monitoring facility to determine the instantaneous release requirement as well as installation of facilities to accommodate changing release flows. Given the limited amount of habitat and small size of trout in Spring Creek upstream of the diversion, we concluded in the draft EIS that the benefit to the fishery from the higher flows proposed by the agencies would be limited.

During the 10(j) meeting held on December 12-14, 2006, the agencies stated that restoration of higher stream flows in Spring Creek would improve its value as a coldwater refugium in the summer and as a warmwater refugium in winter at its confluence with Jenny Creek. They also expressed concern that PacifiCorp's proposed minimum flow of 1 cfs would not provide continuous flow through the length of the bypassed reach, and that the flow would provide only shallow, marginal aquatic habitat, and would be subject to freezing during winter. Subsequent to the 10(j) meeting, Oregon Fish & Wildlife provided additional information on fisheries resources in Spring Creek and on the location and nature of privately owned diversions upstream and downstream of PacifiCorp's diversion on Spring Creek (letter from A. Stuart, Hydropower Program Biologist, Oregon Fish & Wildlife, to the Commission dated February 26, 2007). They noted that an impassable waterfall in lower Jenny Creek isolates Jenny Creek rainbow trout from other populations of this species, and that genetic analysis indicates that they may belong to a unique

subspecies. They state that Jenny Creek rainbow trout are classified as a sensitive species by Oregon Fish & Wildlife, and that the Jenny Creek sucker is a subspecies listed by the FWS as a "Category 2" candidate species, and an Oregon "sensitive-limited distribution" species. Oregon Fish & Wildlife also summarized the results of a fisheries survey conducted by Reclamation in 2000, which resulted in the collection of 23 trout in Shoat Springs Creek (at the headwaters of Spring Creek), 20 trout over about 400 feet of stream surveyed upstream of PacifiCorp's diversion, and three fish collected over 500 feet of stream sampled downstream of the diversion.

Oregon Fish & Wildlife also stated that two private diversions are located 0.1 mile upstream and 0.4 mile downstream of PacifiCorp's Spring Creek diversion, and that the water right for the lower, non-consumptive diversion, provided a minimum flow requirement of 1.56 cfs when it was renewed in 2000. A letter filed by Mr. Taylor, the owner of the diversions, reported that he actually has 4 diversions: a consumptive and non-consumptive diversion with a 7.5 cfs water right located upstream of PacifiCorp's diversion and three non-consumptive diversions located downstream of PacifiCorp's diversion (letter from R. Taylor to the Commission dated January 17, 2007). Mr. Taylor states that the first downstream diversion diverts up to 8.9 cfs to his trout farm and hydroelectric project, a second diversion that is used for his hatchery "as needed," and a third diversion which diverts all flows up to 8.9 cfs into his raceway ponds and that returns these flows directly into Jenny Creek. He also filed pictures of Spring Creek downstream of PacifiCorp's diversion documenting ice-covered conditions in the creek and at the inlet to his rearing ponds.

Discrepancies between Oregon Fish & Wildlife and Mr. Taylor's description of the number of diversions located downstream of PacifiCorp's diversion and of the bypass flows required to be maintained downstream of the Taylor diversions make it difficult to fully evaluate the benefit that would be provided to aquatic habitat in Spring Creek by releasing the 4 cfs minimum flow recommended by the agencies. However, Mr. Taylor's pictures document the extent of freezing that can occur in Spring Creek under low flow conditions, which could greatly reduce invertebrate productivity and cause mortality to trout residing in areas that are frozen during cold periods. Higher flows would therefore increase the overall production of trout and invertebrates in Spring Creek, and the recruitment of food and trout that emigrate downstream into Jenny Creek. A higher minimum flow, such as 4 cfs, would also provide a relatively warm thermal refugium where the flows enter Jenny Creek.

The Oregon Fish & Wildlife, Cal Fish & Game, and FWS recommendation to limit the ramping rate at Spring Creek to 1 inch per hour and 300 cfs per 24 hours would be protective of the fish resources in the stream. Flows in Spring Creek are too low for the 300 cfs restriction to apply. However, given that flow downramping is likely to occur only once each year when diversion restarts in September, any adverse effects due to ramping are likely to be minor.

Iron Gate

Iron Gate development is operated to re-regulate peaking flows from the upstream J.C. Boyle and Copco developments to provide stable flows in the Klamath River downstream of the dam. At flows less than about 1,735 cfs, the Iron Gate turbine can be regulated closely to control ramping rates. At flows more than 1,735 cfs, Iron Gate dam spills and the ability to control downstream flow fluctuations become more difficult because the spillway is an ungated overflow type structure. The concrete spillway has no flow control gates; therefore, spill at Iron Gate is controlled to some degree by operation of the upstream Copco No. 1 and No. 2 developments. Flow control becomes complicated in this flow range (1,735 to 3,200 cfs) because of the influence of turbine discharges, reservoir retention time, reservoir-induced flow attenuation, and tributary inflow between Copco and Iron Gate reservoirs. At flows exceeding 3,200 cfs, flows at Copco No. 1 dam can be controlled only via 13 sets of spill gates, 11 of which are manually operated. The precision of flow control when operating these gates is hindered by their overall size, and, if Copco reservoir is full, control of spill is difficult.

Iron Gate Minimum Flows. The flow regime downstream of Iron Gate dam affects aquatic resources through its influence on physical habitat (depth, velocity, substrate and cover), water quality (especially water temperature), sediment transport processes (including effects on spawning habitat), and conditions that may influence the prevalence of disease pathogens and the spread of fish diseases. Since 1997, PacifiCorp has operated the project to provide instream flow releases that are established in Reclamation's annual operating plans. Operating plans developed since 2002 have been developed to comply with flows specified in the 2002 NMFS BiOp on Reclamation's Klamath Irrigation Project operations (NMFS, 2002). As we describe in section 3.3.2.1.1, *Water Quantity*, Phase III flows specified in the 2002 NMFS BiOp (see table 3-23) went into effect in 2006, as ordered in a March 26, 2006, ruling by the U.S. Ninth Circuit Court of Appeals.

PacifiCorp proposes to maintain the instream flow schedule and ramp rates below Iron Gate dam according to Reclamation's Klamath Irrigation Project Operations Plans, which would be consistent with the 2002 NMFS BiOp.

The Hoopa Valley Tribe, Oregon Fish & Wildlife, Cal Fish & Game, and Forest Service recommend monthly flows that are based on the Hardy Phase II flow study conducted under contract to Interior (Hardy and Addley, 2001). The Hardy Phase II flow recommendations and variations from the Hardy Phase II flows recommended by the agencies and tribes are shown in table 3-66. Monthly flows recommended by the Hoopa Valley Tribe match the Hardy Phase II flow recommendations for each water year type, which are based on annual flow exceedance values of 10, 30, 50, 70, and 90 percent.

Table 3-66. Hardy Phase II and agency flow recommendations. (Source: Staff)

	Water Year Type, Recommending Party, and Flow (cfs)							
	Wet	Above Normal	Average	Below Average		Dry		
Month	(Hardy)	(Hardy)	(Hardy)	(Hardy)	(Forest Service/Cal Fish & Game)	(Hardy)	(Oregon Fish & Wildlife/Cal Fish & Game)	(Forest Service)
April	5,200	4,100	3,300		2,200	1,500	1,600	
May	4,500	3,700	3,100		2,100	1,600	1,600	
June	3,800	2,900	2,300		1,800	1,600	1,350	
July	2,300	1,970	1,530		1,250	1,600	1,200	1,000
August	1,800	1,470	1,250	1,000	1,200	1,600	1,200	
September	1,840	1,570	1,350	1,100	1,200	1,350	1,200	
October	1,900	1,660	1,470		1,200	1,000	1,200	1,100
November	2,200	1,970	1,710		1,400	1,000	1,200	NS
December	3,500	2,400	2,030		1,600	1,000	1,300	NS
January	4,200	2,970	2,400		2,000	1,100	1,500	NS
February	5,000	3,500	2,720		2,200	1,200	1,600	NS
March	5,400	4,300	3,400		2,400	1,300	1,600	NS

NS: Not specified (Forest Service only recommended flows from May through October in all water year types)

To minimize disease risk associated with low flows, Cal Fish & Game recommend that an absolute minimum flow of 1,200 cfs be released in all months and water year types. Oregon Fish & Wildlife applies the same minimum flow of 1,200 cfs in dry years, but not in below average water years. The Forest Service applied the 1,200 cfs minimum flow to all year types, but only for the months of August and September.

Although Oregon Fish & Wildlife and Cal Fish & Game indicate that application of the 1,200 cfs absolute minimum flow was their only change from the Hardy Phase II flows, the monthly flows that they

provided in tabular form deviate substantially from the Hardy Phase II flows in dry water years. This may be a typographical error, however, because their dry year flow recommendations appear to correspond with the Hardy Phase II flows, with the exception of the 1,200 cfs absolute minimum flow, if they are shifted by 3 months.

Oregon Fish & Wildlife states that its flow recommendations are target flows, and that if the target flows are not available, PacifiCorp should pass inflows to Iron Gate reservoir downstream of Iron Gate dam. Cal Fish & Game recommends that, if inflows drop below the recommended minimum flows, PacifiCorp draft Iron Gate reservoir to elevation 2,322 feet, using the available active storage to maintain the minimum flow. After the reservoir elevation drops to below 2,322 feet, Cal Fish & Game recommends that operations at Iron Gate dam convert to run-of-river, with outflow equal to the 3-day running average of inflow. Forest Service recommends that, when the recommended flows are not available, Iron Gate dam be operated as a run-of-river facility. NMFS and FWS recommend that, with the exception of biologically based pulse releases, the project be operated as a run-of-river facility. Releases from Iron Gate dam would equal the combined instantaneous inflow to the project including tributary inflow, spring accretion flow, irrigation return flows, and releases made by Reclamation from its Klamath Irrigation Project. Oregon Fish & Wildlife recommends generally operating Iron Gate dam run-of-river.

Our Analysis

Based on our estimate of the current storage capacity of the project reservoirs (see table 3-17), PacifiCorp controls a total of 12,244 acre-feet of storage in the five mainstem reservoirs that are part of the current project. This represents only 2.5 percent of the storage that is controlled by Reclamation in Upper Klamath Lake, or enough water to augment river flows by about 200 cfs for 30 days. This volume of water may be useful for contributing flow during short-term events, but is not sufficient to allow substantial or long-term augmentation over inflows.

Based on our analysis in section 3.3.3.2.3, *Disease Management*, we conclude that development of an effective disease management plan may be essential to prevent the further decline of populations of fall Chinook salmon in the Klamath River Basin, and the potential spread of disease to other salmonid species. Two components that could be included in such a plan would be evaluating the use of high flow releases prior to the juvenile fall Chinook salmon outmigration to reduce pathogen densities, and increasing flows during the migration season to reduce the density of pathogens, expedite fish movement, and reduce water temperatures during the juvenile fall Chinook salmon outmigration season.

To evaluate what range of flows might be needed to reduce the incidence of disease-related losses of juvenile fall Chinook salmon and other salmonids, we examined flow releases that were made from Iron Gate dam in years when substantial mortality of juvenile fall Chinook salmon migrants have been reported (1997, 2000, 2002, 2004, and 2005), and compared these to average flows for these months from 1997 through 2006, and flows that have occurred in 2006 to date. We include 2006 because of the low incidence of disease that has been reported for 2006 through at least early June (memo from K. True, FWS, to the Klamath Fish Health Distribution List, dated June 8, 2006, accessed at http://ncncr-isb.dfg.ca.gov/KFP/uploads/2006%20pathogen%20monitoring%2009-15.doc on October 30, 2007), which may be related to high flow conditions in 2006. Figure 3-98 shows average monthly flows for these years. Although we found little information in the record on disease incidence in 1997 and 2000, we include those years based on substantial mortality rates reported by Scheiff et al. (2001) during screw-trap sampling at Big Bar.

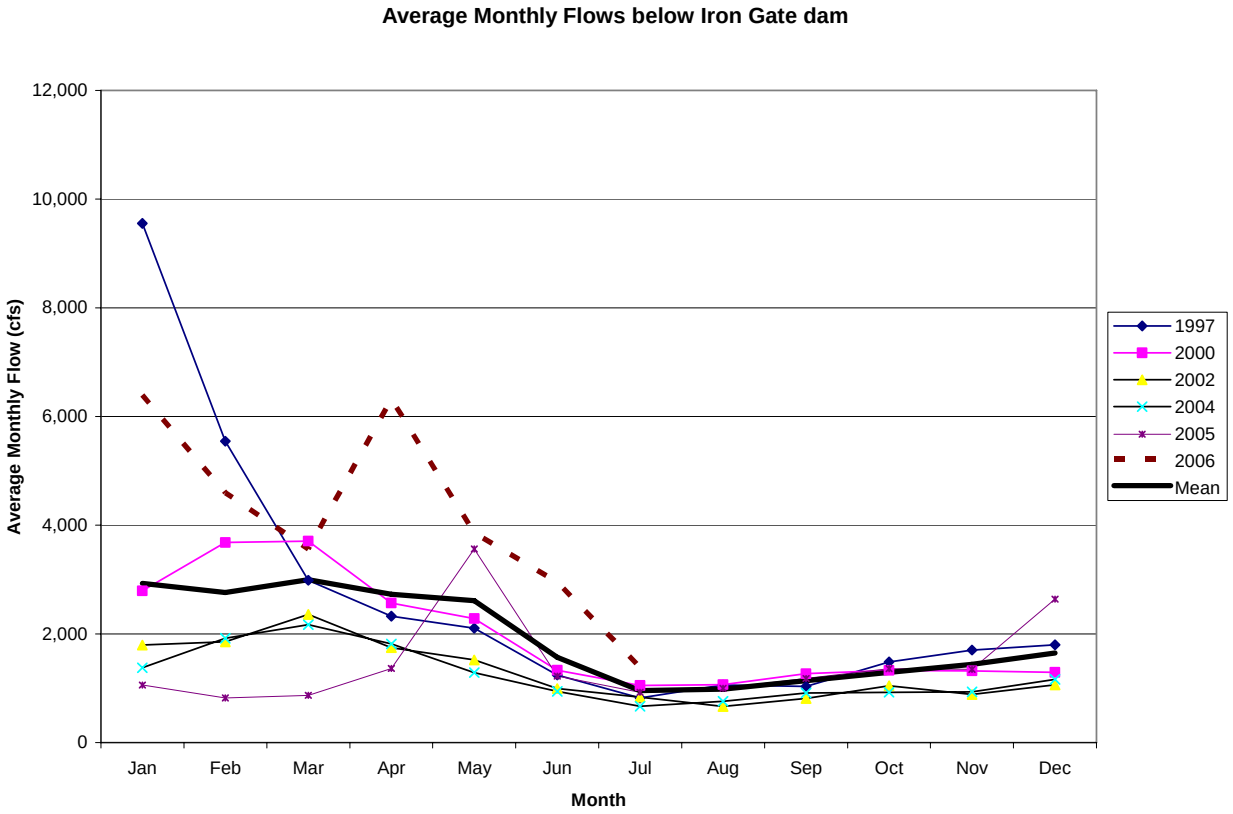


Figure 3-98. Average monthly flows below Iron Gate dam for 1997, 2000, 2002, 2004, 2005 and 2006 to date. (Source: http://waterdata.usgs.gov/nwis/sw [flows through September 2005] and http://www.usbr.gov/mp/kbao/operations/water/kopage.cfm [flows from October 2005 to July 2006] accessed on August 2, 2006)

In years where substantial juvenile mortality or disease incidence was reported (1997, 2000, 2002, 2004, and 2005), flows below Iron Gate dam were below the long-term average for nearly all months during the primary juvenile fall Chinook salmon migration period (May through July). In 2006, flows during the outmigration period were substantially above average, remaining above 3,000 cfs through mid-June. Based on this information, we conclude that maintaining flows of 3,000 cfs or higher may assist with reducing disease-related losses of juvenile migrants in the lower river, which may be essential to prevent further decline of the fall Chinook salmon fishery in the Klamath River. This risk appears to extend to fish produced in tributaries, based on the observed infection rates on fall Chinook salmon emigrating from the Trinity River, which we discuss in section 3.3.3.2.3, *Disease Management*.

Maintaining flows on the order of 3,000 cfs is clearly beyond the flow volumes that can be provided using the active storage that is available in the project reservoirs. Accordingly, in section 3.3.3.2.3, *Disease Management,* we discuss the potential for PacifiCorp to coordinate with Reclamation and other stakeholders to consider opportunities for coordinating the use of available storage in the most effective manner possible.

Because of the limited storage capacity that is under PacifiCorp's control, we conclude that PacifiCorp's proposal to maintain the instream flow schedule below Iron Gate dam according to Reclamation's Klamath Irrigation Project Operations Plans is reasonable and appropriate, since Reclamation controls 97.5 percent of the storage. We see little benefit in Cal Fish & Game's

recommendation that PacifiCorp use the active storage in Iron Gate reservoir to maintain target flows when inflows drop below their recommended monthly flow regime. The limited storage that is available in PacifiCorp's reservoirs would be most valuable for use during short-term emergencies when immediate flow releases are needed to avert impending fish losses based on observed increases in fish losses or adverse water quality conditions. Because of Iron Gate reservoir's proximity to the lower Klamath River, it could be used to augment flows more quickly in emergency situations than flows released from Upper Klamath Lake. These could include releases of cool water from the hypolimnion to provide some short-term cooling of flows below Iron Gate dam. The potential for using releases from the hypolimnion could be evaluated under the temperature management plan that we discuss in section 3.3.2.1.2, *Water Quality*.

We also see little benefit in Forest Service's recommendation that Iron Gate dam be operated as a run-of-river facility when inflows drop below their recommended flows or Oregon Fish & Wildlife's recommendation that Iron Gate dam should be generally operated as run-of-river. Iron Gate dam serves an important re-regulating function to smooth out flow fluctuations from peaking operations at the upstream J.C. Boyle and Copco developments. Implementing run-of-river operations at Iron Gate dam while continuing peaking operations at the upstream developments would result in substantial flow fluctuations downstream of Iron Gate dam; would violate ramping rates specified in the 2002 NMFS BiOp; and could adversely affect aquatic resources through fish stranding, reduced invertebrate production, disruption of spawning activity, and dewatering of salmon redds.

We also see little benefit in the recommendation made by NMFS and FWS that, with the exception of biologically based pulse releases, the project should be operated run-of-river with releases from Iron Gate dam equal the combined instantaneous inflow to the project including tributary inflow, spring accretion flow, irrigation return flows, and releases made from the Klamath Irrigation Project. Because irrigation return flows to Keno reservoir can vary by up to 775 cfs over a 24-hour period, this could result in substantial flow variations downstream of Iron Gate dam and non-compliance with ramping rates specified in the NMFS 2002 BiOp.

Iron Gate Ramping Rates. The ramp rate restriction in the current license at Iron Gate dam is a maximum change of 3 inches per hour (as measured at the USGS gage downstream of the dam) or 250 cfs per hour, whichever is less, "provided that the licensee shall not be responsible for conditions beyond its control." Currently, ramp rates at Iron Gate are consistent with those specified in the 2002 NMFS BiOp. The rates are as follows: (1) decreases in flow to be 300 cfs or less per 24-hour period and not more than 125 cfs per 4-hour period when Iron Gate dam flows are above 1,750 cfs; and (2) decreases in flow to be of 150 cfs or less per 24-hour period and no more than 50 cfs per 2-hour period when Iron Gate dam flows are 1,750 cfs or less.

PacifiCorp proposes to maintain the instream flow schedule and ramp rates downstream of Iron Gate dam according to Reclamation's Klamath Irrigation Project Operations Plans consistent with the 2002 NMFS BiOp. NMFS also recommends the ramping rates specified in the 2002 NMFS BiOp.

Oregon Fish & Wildlife and FWS recommend the same ramp rates, except that, when flows are above 1,750 cfs, downramping would be limited to 125 cfs per hour instead of 125 cfs per 4 hours. Cal Fish & Game and Forest Service recommend that controllable ramp rates not exceed 1 inch per hour at any time.

Our Analysis

Downramping of flow has the potential to result in fish stranding, especially for fry and juvenile salmonids that favor shallow-water habitats along river margins. PacifiCorp reports that only one fish stranding or entrapment incident has been documented downstream of Iron Gate dam, at a site about 20

miles downstream of Iron Gate dam.[77] This event occurred at a time when flows were above the range that can be controlled by the project. Because Iron Gate dam has an uncontrolled spillway, outflows can only be controlled when flows are at or below the project's hydraulic capacity of 1,735 cfs.

PacifiCorp reports that the ramp rates stipulated in the 2002 NMFS BiOp equate to about 0.4 inch per hour at the USGS gage (no. 11516530) about 0.5 mile below the dam. Based on 10 available cross sections between Iron Gate dam and Interstate 5 from Hardy and Addley (2001), PacifiCorp estimates that 0.4 inch per hour at the USGS gage equates to about 0.25 inch per hour in wider areas of the river where stranding potential would be greatest, and that ramping rates become further attenuated downstream.

Because fish stranding has not been observed at current ramping rates when flows have been within the range that the project can control, we conclude that the current rates specified in the 2002 NMFS BiOp appear to be protective of salmonids rearing and emigrating through the lower Klamath River. These rates are considerably more conservative than the ramping rates in effect at many other hydroelectric projects, and are equal to or more conservative than the ramping rates recommended by the agencies for this development. Although it is possible that less conservative ramping rates may be nearly as protective, the conservative ramp rates specified in the 2002 NMFS BiOp appear to be appropriate given the presence of federally listed coho salmon and the importance of the fall Chinook salmon fishery in the mainstem of the Klamath River. In addition, PacifiCorp has not reported any substantial operational difficulties or adverse economic effects related to compliance with the ramping rates specified in the NMFS 2002 BiOp.

Outages and Maintenance Events. PacifiCorp proposes and Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp consult with state, federal, and tribal agencies to identify the preferred timing of facility maintenance for project-dewatered reaches. Scheduled maintenance should be planned to occur either (1) during high flow conditions, so that resulting high flows would coincide with the high-flow period of the natural hydrograph identified by the agencies, and to prevent non-compliance with water quality standards or objectives or (2) during the extreme low flow period when diversion canals will be at their lowest diversion rate and may already be shut down to meet minimum flow requirements. Any changes in flows would be subject to ramping rate requirements. Emergency maintenance may be conducted, if needed, but ramping rates would apply following unscheduled maintenance.

Our Analysis

Consultation with state, federal, and tribal agencies, as appropriate to identify the preferred timing of facility maintenance for project-dewatered reaches would be an effective means for the licensee to take advantage of resource agency knowledge about affected resources, and should help to minimize any adverse effects on aquatic resources. This recommendation would apply to shutdowns at East Side and West Side (if not decommissioned) and J.C. Boyle and Copco No. 2 developments, which may affect flows in bypassed reaches.

[77]PacifiCorp reports that, in April 1998, an artificial spawning channel became isolated from the main river entrapping several hundred salmonid fry, mostly Chinook salmon, in three pools. The channel became isolated as main river flows declined from 4,363 to 1,987 cfs following a high flow event. The total drop in stage in the main river near the spawning channel site exceeded 3 feet. The average rate of flow decline during the 3-day period was 33 cfs per hour, which equates to a 0.4-inch per hour stage drop at the Iron Gate gage.

3.3.3.2.2 Fish Passage

Facility-specific Recommendations

Numerous stakeholders have expressed strong interest in restoring passage of anadromous fish to habitat within and upstream of the project area, either through implementing fish passage measures at project facilities or through dam removal. A successful fish passage program has the potential to increase fish production by allowing anadromous fish to use historical production areas within and upstream of the project and would provide access to important thermal refugia, most notably in the J.C. Boyle bypassed reach and in tributaries upstream of Upper Klamath Lake. Providing effective fish passage at the project would also benefit resident fish species, including rainbow trout, by increasing habitat connectivity and by reducing mortality caused by entrainment and turbine passage. We evaluate fish passage recommendations for each facility below. We evaluate the effects of dam removal on fish passage in section 3.3.3.2.4, *Dam Removal or Decommissioning*, and we compare alternative approaches for restoring anadromous fish to historic habitats in section 3.3.3.2.5, *Anadromous Fish Restoration*.

East and West Side Developments. PacifiCorp does not propose to provide passage for anadromous fish to any areas upstream of Iron Gate dam or to implement any fish passage measures associated with East and West Side developments. As we discuss in section 3.3.3.2.4, *Dam Removal or Decommissioning*, PacifiCorp proposes to decommission its East Side and West Side developments, and has proposed to exclude these facilities and Keno dam from the project.

In their preliminary and modified joint fishway prescriptions, NMFS and Interior prescribe that PacifiCorp design and construct fish screen and bypass facilities at East Side and West Side developments as close as possible to the beginning of each diversion canal to provide effective downstream passage for Chinook salmon, steelhead, Pacific lamprey, federally listed suckers, and rainbow trout. The facilities would divert all fish to a holding, sorting, counting, and tagging facility where fish would either be passed to a volitional fishway or into temporary, seasonal trap and haul facilities for downstream transport between June 15 and November 15. If agreed to by NMFS and FWS, trap and haul would not occur when DO is greater than 6 mg/L and temperature is lower than 15°C at Miller Island, located at RM 246 in Keno reservoir. The screen and bypass facility would be operated year-round, designed in accordance with sucker criteria, and include provisions to return suckers to Upper Klamath Lake. NMFS and FWS also prescribe that PacifiCorp construct tailrace barriers and guidance systems within 3 years at the East Side and West Side powerhouses to protect adult fish. As we discuss later in this section, the joint NMFS/Interior prescription also includes the construction of volitional upstream and downstream fish passage facilities at the Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams and the Spring Creek and Fall Creek diversions. Tailrace barriers are prescribed at all powerhouses except at Iron Gate dam. Cal Fish & Game and Oregon Fish & Wildlife both recommend that PacifiCorp install tailrace barriers at all project powerhouses, and evaluate the hydraulic and biological performance of each facility.

PacifiCorp filed an alternative to the preliminary joint NMFS/Interior fishway prescription on April 25, 2006, which includes trapping and hauling adult salmon and/or steelhead from Iron Gate dam to J.C. Boyle reservoir, and potentially to other locations in the upper basin. If fisheries managers decide that self-sustaining runs of anadromous fish can be established, a juvenile trap and haul facility would be constructed at or above J.C. Boyle dam, and smolts would be transported past the project reservoirs and released downstream of Iron Gate dam. We interpret PacifiCorp's alternative prescription to encompass locating the smolt collection facility as far upstream of J.C. Boyle as Link River dam, at East Side or West Side developments. PacifiCorp filed a second alternative to NMFS/Interior's preliminary fishway prescription on December 1, 2006. This second alternative includes installing volitional downstream passage facilities at all mainstem dams, volitional upstream passage at J.C. Boyle, construction of a second adult trap at Copco No. 2 dam, and use of trap and haul for upstream passage at the lower three dams. We evaluate the alternative approaches reflected by fishway prescriptions and alternative prescriptions in section 3.3.3.2.5, and the potential benefits of facilities installed at each dam below.

Our Analysis

Providing passage for anadromous fish to areas upstream of Link River dam would provide access to a substantial amount of habitat in tributaries to Upper Klamath Lake, and to potential rearing habitat in spring-influenced sections of Upper Klamath Lake. Reclamation's fish ladder at Link River dam, completed in 2005, is designed to pass federally listed suckers, but also would enable anadromous fish to pass from Link River to Upper Klamath Lake. Huntington (2006) estimates that there are 355.6 miles of existing stream habitat that is currently or was recently capable of supporting anadromous salmonids in tributaries to Upper Klamath Lake and another 70.4 miles that he considers recoverable within the next 30 to 50 years (table 3-67). Although much of this habitat has been degraded, substantial portions in the Wood and Williamson river systems are considered to be in good condition (Huntington et al., 2006), and habitat conditions are expected to improve over time, due to numerous ongoing restoration efforts in the upper basin (FWS, 2006c).

Table 3-67. Estimates of existing and recoverable anadromous fish habitat in tributaries to Upper Klamath Lake. (Source: Huntington, 2006, as modified by staff)

	Anadromous Fish Habitat (miles)	
Location	**Existing**	**Existing plus Recoverable**
Westside tributaries (including the Wood River and Seven mile Creek)	63.3	114.0
Williamson River system (excluding Sprague River)	30.4	30.4
Sprague River system	261.9	281.6
Total	355.6	426.0

Installation of downstream fish passage facilities at East Side and West Side developments, including facilities for trapping and transporting downstream migrating smolts, as specified by Interior and NMFS, could facilitate any future efforts to restore upstream anadromous fish runs by allowing smolts to be collected and trucked to the lower river, thereby avoiding mortality associated with passage through the section of the river that would be bypassed. PacifiCorp proposes to decommission both the East Side and West Side developments, and if these two developments are not included in a new license for this project, the Commission could not require PacifiCorp to install downstream fish passage facilities at either development. DO levels in Keno reservoir typically diminish to stressful levels (less than 6 mg/L) by early July (figure 3-99), and analysis of water temperatures and DO levels conducted by Dunsmoor and Huntington (2006) shows that thermal conditions in much of the river between Keno and Iron Gate dams are severely stressful to juvenile salmonids by mid-June (tables 3-68 through 3-71). Collecting and transporting smolts past the project reservoirs would avoid mortality associated with locally poor water quality conditions, predatory fish in project reservoirs, and injuries while passing through multiple fish screening facilities. Transporting fish past the project reservoirs would be likely to reduce travel time, and could increase the number of smolts that pass through the lower river before water temperatures approach severely stressful levels. Speeding up juvenile outmigration would especially benefit fall Chinook salmon, which migrate downstream later in the season than spring Chinook salmon and steelhead. Releasing transported smolts 50 or more miles downstream of Iron Gate dam could reduce their exposure to pathogens, which are especially prevalent in the first 50 miles downstream of Iron Gate dam (see section 3.3.3.2.3). We note, however, that juvenile and adult anadromous fish reintroduced to Upper Klamath Lake could be exposed to *C. shasta* in the basin upstream of Link River dam. Oregon State University (2004) found that the Williamson River, a key tributary to Upper Klamath Lake where habitat is considered to be suitable for anadromous fish restoration, had the second-highest concentration of *C. shasta* of all of the sites that they sampled.

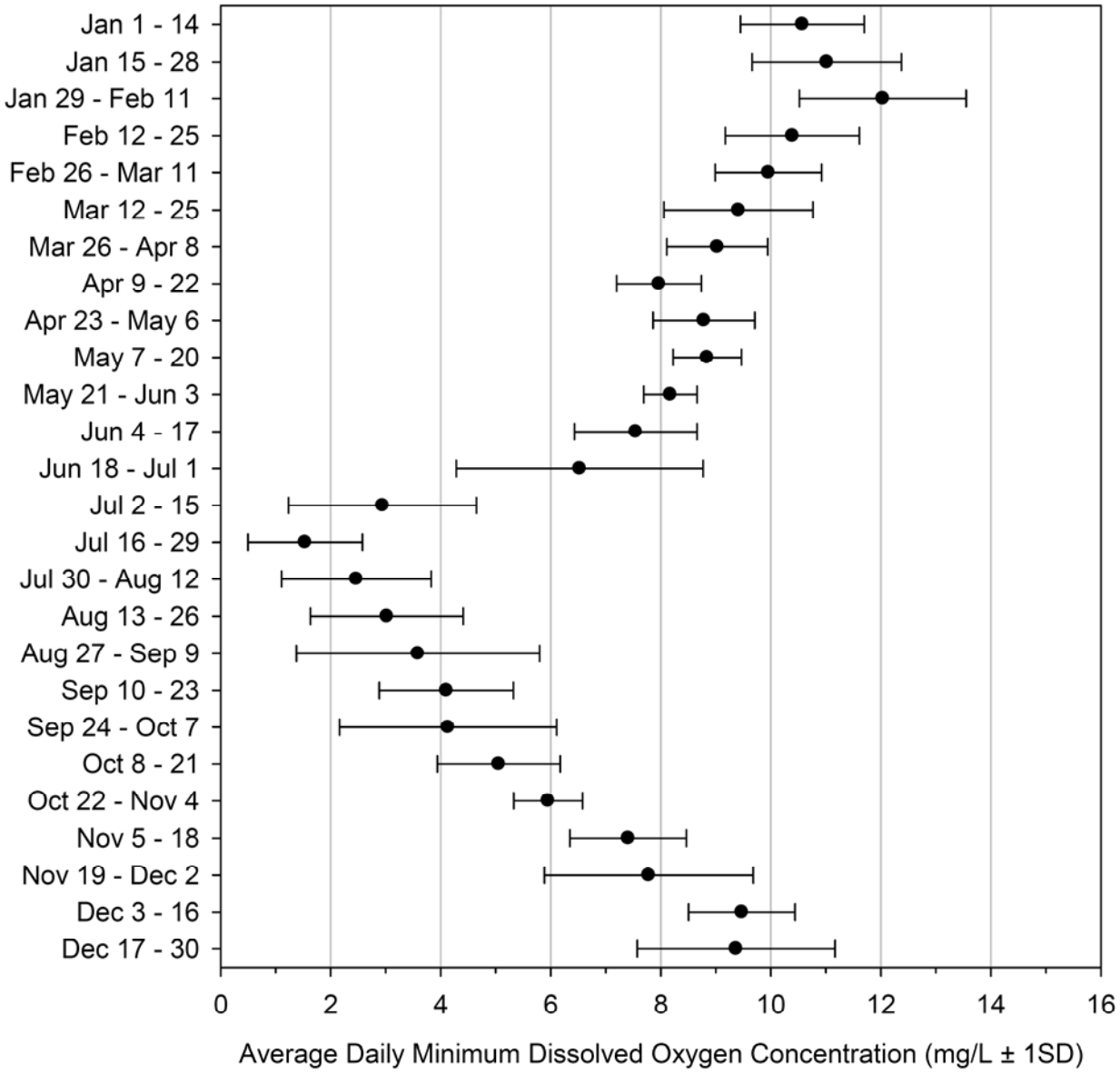


Figure 3-99. Daily minimum DO conditions in Keno reservoir. Daily minima calculated from hourly data and averaged over 1-3 sites in Keno reservoir from January 2002 – December 2004. Standard deviations calculated from daily averages. (Source: Dunsmoor and Huntington, 2006)

Table 3-68. Criteria for water temperature and DO concentration used to classify levels of stress for anadromous salmonids. Thresholds between the four levels of stress are averages of daily minima (7d-min), mean (7d-avg), or maxima (7d-max), calculated for the previous 7 days. (Source: Dunsmoor and Huntington, 2006)

			Upper threshold				Intermediate threshold				Lower threshold			
Constituent	Life stage	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition	7d-min	7d-avg	7d-max	Condition
Water temperature (°C)	Adult migration (through July 31)	Optimal (OPT)[1]		16	18	Suboptimal (SUB)[2]		18	20	Stressful (STR)[3]		<2 or >20	21	Severely Stressful - refugial areas critical (SEV)[4]
	Adult migration (from Aug 1)			16	18			19	20			<2 or >21	22	
	Chinook juvenile rearing			15	16			18	21			21	23	
	Steelhead juvenile rearing			16	18			19	22			22	24	
Dissolved oxygen (mg/L)	All life stages		6	8			5.5				5			

[1] Optimal - conditions placing very little or no constraint on the life stage.

[2] Suboptimal - conditions that are mildly to moderately stressful unless there are significant ameliorating factors (e.g. presence of a highly abundant food supply for juvenile fish).

[3] Stressful - conditions that are moderately to severely stressful. Temperature becomes an increasingly critical factor affecting fish distribution, abundance, growth, and/or survival. Thermal refugia and/or ameliorating conditions are important under these conditions.

[4] Severely stressful - conditions under which fish survival is jeopardized to the extent that the ability to find spatial and/or temporal refuge is likely to be essential to fish presence. Fish migrations may be blocked, or fish may well be elsewhere, under these conditions.

Table 3-69. Thermal stress level for juvenile Chinook salmon based on temperature and DO levels predicted by the Klamath River water quality model. Values shown are the percentage of days falling within stress categories for each 2 week period based on simulations from 2000 to 2004. Stress categories are: OPT = optimal, SUB = suboptimal, STR = stressful, and SEV = severely stressful as determined using the criteria shown in table 3-68. (Source: Dunsmoor and Huntington, 2006, as modified by staff)

Keno to J.C. Boyle Powerhouse

Biweekly Period	Fall Chin. Juvenile Migration	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		90	10			80	20			91	9			100				97	3		
May 7 - 20		56	44			44	56			57	43			90	10			77	23		
May 21 - Jun 3		3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16	
Jun 4 - 17				76	24		1	76	23			79	21		100				71	29	
Jun 18 - Jul 1				31	69			33	67			44	56		100				51	46	3
Jul 2 - 15				14	86			4	96			14	86		100				16	70	14
Jul 16 - 29					100				100			1	99		100				1	56	43
Jul 30 - Aug 12					100				100			3	97		100				17	49	34
Aug 13 - 26					100				100			10	90		100				23	70	7
Aug 27 - Sep 9			3	31	66		4	23	73		4	57	39	6	94				71	29	
Sep 10 - 23			37	63			46	54			41	59		27	73			1	99		
Sep 24 - Oct 7		3	91	6			99	1		6	91	3		84	16			31	69		
Oct 8 - 21		71	29			60	40			80	20			100				96	4		
Oct 22 - Nov 4		100				100				100				100				100			

J.C. Boyle Powerhouse to above Shasta River

Biweekly Period	Fall Chin. Juvenile Migration	At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57				At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		80	20			77	23			100				100				100			
May 7 - 20		39	61			33	67			63	37			100				44	56		
May 21 - Jun 3			67	33			59	41		20	66	14		61	37	1		9	87	4	
Jun 4 - 17			36	46	19		37	43	20		40	60			64	36			50	50	
Jun 18 - Jul 1			7	41	51		4	61	34		6	93	1		30	70			3	74	23
Jul 2 - 15				17	83			19	81			41	59			100				1	99
Jul 16 - 29				10	90			13	87			9	91			59	41				100
Jul 30 - Aug 12				27	73			30	70			7	93			23	77				100
Aug 13 - 26				19	81			49	51			9	91			20	80				100
Aug 27 - Sep 9			17	54	29		19	63	19			50	50			43	57			33	67
Sep 10 - 23			99	1			90	10			4	96				97	3		6	77	17
Sep 24 - Oct 7		9	91			9	91				74	26			34	66			36	64	
Oct 8 - 21		76	24			77	23			34	66				100				99	1	
Oct 22 - Nov 4		100				100				100				90	10			79	21		

above Shasta River to above Salmon River

Biweekly Period	Fall Chin. Juvenile Migration	At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		100				100				97	3			100				100			
May 7 - 20		64	36			59	41			76	24			83	17			90	10		
May 21 - Jun 3		14	69	17		11	66	23		14	69	17		34	51	14		41	54	4	
Jun 4 - 17			47	53			50	50			74	26			89	11			90	10	
Jun 18 - Jul 1				90	10			81	19			86	14		24	63	13		24	60	16
Jul 2 - 15				34	66			26	74			53	47			67	33			67	33
Jul 16 - 29				6	94			3	97			4	96			17	83			24	76
Jul 30 - Aug 12				10	90			9	91			11	89			24	76			26	74
Aug 13 - 26				6	94			7	93			14	86			29	71			40	60
Aug 27 - Sep 9			1	44	54		3	44	53		3	43	54		4	56	40		4	60	36
Sep 10 - 23			10	90			11	79	10		13	79	9		23	59	19		34	46	20
Sep 24 - Oct 7			41	59			41	59			40	60		4	40	56		7	40	53	
Oct 8 - 21		23	76	1		13	84	3		27	70	3		30	67	3		40	57	3	
Oct 22 - Nov 4		94	6			90	10			93	7			93	7			96	4		

Migration

Peak migration

thermal conditions suboptimal at least 50% of the time

thermal conditions stressful at least 50% of the time

thermal conditions severely stressful at least 50% of the time (temperature refugia critical)

Table 3-70. Thermal stress level for juvenile steelhead based on temperature and DO levels predicted by the Klamath River water quality model. Values shown are the percentage of days falling within stress categories for each 2 week period based on simulations from 2000 to 2004. Stress categories are: OPT = optimal, SUB = suboptimal, STR = stressful, and SEV = severely stressful as determined using the criteria shown in table 3-68. (Source: Dunsmoor and Huntington, 2006, as modified by staff)

Keno to J.C. Boyle Powerhouse

Biweekly Period	Steelhead Juvenile Migration	At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		97	3			99	1			99	1			100				100			
May 7 - 20		76	24			79	21			77	23			100				90	10		
May 21 - Jun 3		27	40	29	4	23	50	27		27	44	29		100				53	37	10	
Jun 4 - 17			21	63	16		34	49	17		24	61	14	83	17			3	77	20	
Jun 18 - Jul 1			3	60	37		7	41	51		4	70	26	63	37				79	21	
Jul 2 - 15				19	81			14	86			21	79	21	79				26	73	1
Jul 16 - 29				3	97				100			16	84	11	89				30	49	21
Jul 30 - Aug 12				6	94				100			16	84	27	73				36	53	11
Aug 13 - 26				23	77			7	93			43	57	53	47				60	40	
Aug 27 - Sep 9			6	90	4		7	63	30		7	91	1	99	1			4	96		
Sep 10 - 23			71	29			74	26		6	74	20		100				47	53		
Sep 24 - Oct 7		30	67	3		13	87			41	59			100				97	3		
Oct 8 - 21		93	7			87	13			96	4			100				100			
Oct 22 - Nov 4		100				100				100				100				100			

J.C. Boyle Powerhouse to above Shasta River

Biweekly Period	Steelhead Juvenile Migration	At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57				At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		97	3			97	3			100				100				100			
May 7 - 20		79	21			74	26			93	7			100				100			
May 21 - Jun 3		20	64	16		13	59	29		54	40	6		80	20			41	59		
Jun 4 - 17			70	16	14		73	13	14		76	24		23	76	1			97	3	
Jun 18 - Jul 1			27	51	21		29	49	23		34	66			63	37			33	61	6
Jul 2 - 15			3	34	63		4	34	61		3	96	1		13	87				54	46
Jul 16 - 29				39	61		6	31	63			59	41			93	7			6	94
Jul 30 - Aug 12			6	40	54		13	37	50			39	61			61	39			4	96
Aug 13 - 26			1	71	27		4	81	14			51	49			70	30			9	91
Aug 27 - Sep 9		1	36	63		3	43	54				99	1			100			1	47	51
Sep 10 - 23		13	87			19	81				46	54			10	90			19	81	
Sep 24 - Oct 7		63	37			53	47				97	3			87	13			84	16	
Oct 8 - 21		97	3			99	1			66	34			30	70			41	59		
Oct 22 - Nov 4		100				100				100				100				100			

above Shasta River to above Salmon River

Biweekly Period	Steelhead Juvenile Migration	At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
		OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6		100				100				100				100				100			
May 7 - 20		99	1			97	3			84	16			96	4			100			
May 21 - Jun 3		34	63	3		33	60	7		59	27	14		64	36			66	34		
Jun 4 - 17			86	14			90	10		1	90	9		14	81	4		14	81	4	
Jun 18 - Jul 1			20	77	3		17	76	7		27	67	6		47	50	3		50	47	3
Jul 2 - 15				71	29			64	36			73	27			77	23		4	74	21
Jul 16 - 29				26	74			10	90			26	74			54	46			66	34
Jul 30 - Aug 12				26	74			26	74			26	74		4	33	63		4	34	61
Aug 13 - 26				46	64			39	61			49	51		4	66	30		4	69	27
Aug 27 - Sep 9			10	60	30		13	54	33		14	61	24		17	70	13		19	69	13
Sep 10 - 23			34	66			41	59			44	56		1	50	49		1	59	37	3
Sep 24 - Oct 7		6	73	21		7	67	26		9	64	27		9	69	23		9	70	21	
Oct 8 - 21		66	34			67	33			69	31			71	27	1		73	26	1	
Oct 22 - Nov 4		100				100				100				100				100			

Migration

thermal conditions suboptimal at least 50% of the time
thermal conditions stressful at least 50% of the time
thermal conditions severely stressful at least 50% of the time (temperature refugia critical)

Table 3-71. Thermal stress level for adult anadromous salmonids based on temperature and DO levels predicted by the Klamath River water quality model. Values shown are the percentage of days falling within stress categories for each 2 week period based on simulations from 2000 to 2004. Stress categories are: OPT = optimal, SUB = suboptimal, STR = stressful, and SEV = severely stressful as determined using the criteria shown in table 3-68. (Source: Dunsmoor and Huntington, 2006, as modified by staff)

Keno to J.C. Boyle Powerhouse

Biweekly Period	Adult Migration				At Keno Dam RM 232.86				Abv JC Boyle reservoir RM 227.57				At JC Boyle Dam RM 224.32				Abv JCB Powerhouse RM 220.20				Blw JCB Powerhouse RM 219.40			
	fall Chin	spr Chin	sthd	coho	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6					90	10			80	20			91	9			100				97	3		
May 7 - 20					56	44			44	56			57	43			90	10			77	23		
May 21 - Jun 3					3	53	33	11		57	33	10	6	53	31	10	36	64			23	61	16	
Jun 4 - 17							76	24		1	76	23			79	21		100				71	29	
Jun 18 - Jul 1							31	69			33	67			44	56		100				51	46	3
Jul 2 - 15							14	86			4	96			14	86		100				16	70	14
Jul 16 - 29								100				100			1	99		100				1	56	43
Jul 30 - Aug 12								100				100			3	97		100				17	49	34
Aug 13 - 26								100				100			10	90		100				23	70	7
Aug 27 - Sep 9						3	31	66		4	23	73		4	57	39	6	94				71	29	
Sep 10 - 23						37	63			46	54			41	59		27	73			1	99		
Sep 24 - Oct 7					3	91	6			99	1		6	91	3		84	16			31	69		
Oct 8 - 21					71	29			60	40			80	20			100				96	4		
Oct 22 - Nov 4					100				100				100				100				100			

J.C. Boyle Powerhouse to above Shasta River

Biweekly Period	Adult Migration				At State Line RM 209.16				Abv Copco Reservoir RM 203.61				At Copco Dam RM 198.57				At Iron Gate Dam RM 190.54				Above Shasta River RM 177.52			
	fall Chin	spr Chin	sthd	coho	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6					80	20			77	23			100				100				100			
May 7 - 20					39	61			33	67			63	37			100				100			
May 21 - Jun 3						67	33			59	41		20	66	14		80	19	1		41	43	16	
Jun 4 - 17						36	46	19		37	43	20		40	60		23	41	36			37	44	19
Jun 18 - Jul 1						7	41	51		4	61	34		6	93	1		30	70				4	96
Jul 2 - 15							17	83			19	81			41	59			53	47				100
Jul 16 - 29							10	90			13	87			9	91				100				100
Jul 30 - Aug 12							27	73			30	70			7	93			14	86				100
Aug 13 - 26							19	81			49	51			9	91			20	80				100
Aug 27 - Sep 9						17	54	29		19	63	19			50	50			43	57			13	87
Sep 10 - 23						99	1			90	10			4	96			10	87	3		3	44	53
Sep 24 - Oct 7					9	91			9	91				74	26			87	13			29	70	1
Oct 8 - 21					76	24			77	23			34	66			30	70			41	56	3	
Oct 22 - Nov 4					100				100				100				100				100			

above Shasta River to above Salmon River

Biweekly Period	Adult Migration				At Walker Bridge RM 156.79				Above Scott River RM 143.86				At Seiad Valley RM 129.04				Above Clear Creek RM 99.04				Above Salmon River RM 66.91			
	fall Chin	spr Chin	sthd	coho	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV	OPT	SUB	STR	SEV
Apr 23 - May 6					100				100				100				100				100			
May 7 - 20					99	1			97	3			84	16			96	4			100			
May 21 - Jun 3					34	49	17		33	44	20	3	59	24	4	13	64	21	14		66	30	4	
Jun 4 - 17						47	53			47	50	3	1	73	19	7	14	74	11		14	76	10	
Jun 18 - Jul 1							66	34			20	80			40	60		24	27	49		24	37	39
Jul 2 - 15								100				100				100			7	93			17	83
Jul 16 - 29								100				100				100				100				100
Jul 30 - Aug 12							4	96			3	97			4	96			11	89			14	86
Aug 13 - 26								100			3	97			4	96			14	86			20	80
Aug 27 - Sep 9						10	31	59		3	21	76		9	21	70		9	34	57		13	43	44
Sep 10 - 23						26	74			13	54	33		23	49	29	1	37	27	34	1	46	21	31
Sep 24 - Oct 7					6	73	21		7	41	50	1	9	53	39		9	51	39	1	9	59	31	1
Oct 8 - 21					66	34			67	31	1		69	30	1		71	27	1		73	26	1	
Oct 22 - Nov 4					100				100				100				100				100			

Migration

Peak migration

thermal conditions suboptimal at least 50% of the time

thermal conditions stressful at least 50% of the time

thermal conditions severely stressful at least 50% of the time (temperature refugia critical)

Installation of fish screens at East Side and West Side developments could protect juvenile and adult suckers from mortality that may be caused during turbine passage. The survival rate of larval suckers, however, could be reduced if fish screens are installed. Because of the small size and fragility of fish in their larval lifestage, there may be a substantial risk of impingement and mortality of larval fish that are entrained into a fish screening facility. The same risk is present for migrating immature lamprey, which are poor swimmers and have been found to be susceptible to impingement on fish screens, especially at higher velocities (Moursund et al., 2000). Constructing a screening facility that would reduce the risk of impingement for larval suckers and juvenile lamprey could substantially increase the footprint of the facility, thus increasing potential environmental effects during construction. To our knowledge, proven criteria for safely screening these life stages have not yet been developed.

The ability of juvenile anadromous salmonids to successfully rear and emigrate through Upper Klamath Lake is a critical uncertainty that needs to be addressed before the benefits of installing downstream fish passage facilities at East Side and West Side developments can be fully assessed. Based on an assessment of water quality monitoring conducted from 1990 to 2004, Dunsmoor and Huntington (2006) conclude that water quality conditions in Upper Klamath Lake are adequate to support anadromous fish migration during the spring months into early June. Conditions in the main body of the lake become too warm to support salmonids in mid-summer, but conditions become suitable again between mid-August and early September. They note, however, that the available monitoring data has been collected to the west of what they consider the most likely migratory route for juvenile salmonids; a band of water along the eastern shoreline where currents helpful to fish migration are present. We discuss approaches for addressing this uncertainty in section 3.3.3.2.5, *Anadromous Fish Restoration*.

Another uncertainty to be addressed before installing facilities to provide passage for anadromous salmonids at any of the mainstem developments is the future condition of the migratory corridor downstream of Iron Gate dam. As we discuss in section 3.3.3.2.3, *Disease Management*, continuation of current warming trends in the basin would be likely to exacerbate conditions that are causing substantial losses of juvenile fall Chinook salmon during the outmigration season, and that caused the major die-off of adult anadromous salmonids that occurred in September 2002. In the same section, we evaluate measures that could help to alleviate disease-related fish losses in the downstream migratory corridor. High water temperatures and low DO levels within and downstream of the project are particularly problematic for fall Chinook salmon, because their upstream and downstream migration periods both overlap with the summer period when stressful conditions are most severe (tables 3-69 and 3-71).

With regard to Cal Fish & Game and Oregon Fish & Wildlife's recommendation to install tailrace barriers at all project powerhouses and NMFS/Interior's prescription to install tailrace barriers at most developments including East Side and West Side, none of the agencies have provided any specific evidence of injury or migration delay of upstream migrating fish that would indicate the need for a tailrace barrier at any of the project powerhouses. We conclude that the potential need for and benefits of installing tailrace barriers cannot be fully assessed at this time. We note that PacifiCorp, NMFS, and Interior have come to agreement on a stipulation that if volitional fish passage is prescribed at any of the project facilities, PacifiCorp would study the need for and design of spillway modifications and tailrace barriers for anadromous and native resident fish and that NMFS and FWS would base the need to implement spillway modifications and tailrace barriers on the results of the studies and other available information. This provision is included in the NMFS and Interior modified joint fishway prescription.

Keno Development. PacifiCorp has not proposed to implement any fish passage measures associated with Keno dam. PacifiCorp proposes to continue current operations, which we assume would include continued operation of the existing fish ladder, but the dam would be operated under the jurisdiction of the state of Oregon.

Cal Fish & Game recommends that PacifiCorp equip all project dams with volitional upstream passage facilities within 6 years. The fishways would be designed in consultation with the management

agencies and tribes to operate year-round and to provide for uninterrupted passage of fish over the full range of river flows under which PacifiCorp has control. Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp design and construct a fish ladder at Keno dam with a maximum gradient of 4 percent, two entrances, a screened auxiliary water system, and provisions for visual monitoring or a fish trap and counting system. Oregon Fish & Wildlife recommends that the ladder be constructed within 3 years, and the Hoopa Valley Tribe recommends that the ladder be constructed within 5 years.

Cal Fish & Game also recommends that all project spillways be modified in consultation with the management agencies to improve downstream passage within 6 years, including a post-construction performance evaluation. Oregon Fish & Wildlife recommends that PacifiCorp prepare a biological evaluation plan to determine whether spillway modifications are necessary at Keno dam and implement any needed modifications within 4 years.

NMFS and Interior prescribe that PacifiCorp modify the existing fish ladder at Keno dam to accommodate upstream passage for Chinook and coho salmon, steelhead, and Pacific lamprey, including a screened auxiliary water system that provides forebay water of the correct water quality and quantity to effectively attract fish. The facility would include a holding and sorting facility to accommodate seasonal trap and haul for adult anadromous salmonids. NMFS and Interior also prescribe that PacifiCorp evaluate and implement spillway modifications to improve downstream passage for the same species listed for upstream passage.

Our Analysis

Provision of enhanced upstream passage at Keno dam as part of a future restoration effort could provide access to 20.1 miles of reservoir habitat and 1.2 miles of riverine habitat between the Keno and Link River dams and about 355 miles of habitat in tributaries to Upper Klamath Lake. We note, however, that passage into Upper Klamath Lake and Keno reservoir presents uncertainties regarding the ability of smolts to migrate through these water bodies before water quality conditions degrade in the early summer, and migration through Upper Klamath Lake presents the additional challenge of migrating through a very large body of water with a substantial residence time and limited velocity cues. Although it is clear that the anadromous fish stocks that historically used this habitat were able to migrate through Upper Klamath Lake, the ability of re-introduced stocks to accomplish this portion of their migration under present-day conditions is a critical uncertainty that needs to be addressed if a program to reintroduce anadromous fish to habitat upstream of Upper Klamath Lake is undertaken.

Much of the habitat in Keno reservoir has been channelized, and suffers from very poor water quality conditions including extremely low DO levels from July through September (see figure 3-99). As a result of the poor water quality conditions, the habitat between Keno and Link River dams currently has little potential for producing anadromous fish, and could seasonally create a barrier for anadromous fish passage. The existing fish ladder at Keno dam does not meet current agency criteria, and its ability to pass anadromous fish species is unknown, because anadromous fish were blocked from the area when Copco No. 1 dam was built in 1918, before the Keno dam and fish ladder were constructed. However, FWS and NMFS state in their comments on the draft EIS that they do not believe that the ability of the Keno ladder to pass salmon and steelhead, when it is properly maintained, is in question at this time.

Installation of a fish ladder with a gradient of 4 percent, as recommended by Oregon Fish & Wildlife and the Hoopa Valley Tribe, would facilitate upstream passage for sucker species, including the federally listed shortnose and Lost River suckers. However, provision of upstream passage over Keno dam would expose upstream migrating suckers to some of the worst water quality conditions in the basin, where DO can drop to lethal levels during the summer months. Other methods of returning suckers to Upper Klamath Lake, such as transporting suckers collected in any downstream fish passage facilities that may be constructed at downstream developments, could involve less risk of mortality. There may also be

a conservation benefit provided by allowing suckers that emigrate downstream from Upper Klamath Lake as juveniles to grow to maturity in the reservoirs where they take up residence. Both of the listed species are long-lived (20+ years), and the existence of some adult fish in the downstream reservoirs could serve as a source of broodstock if they are needed for future restoration efforts. Given the occurrence of several massive fish kills in Upper Klamath Lake that resulted in federal listing of the Lost River and shortnose suckers (FWS, 2002), there is some risk that a population collapse could occur.

Subsequent to discussion of sucker passage issues at the 10(j) meeting held in December 2006, Oregon Fish & Wildlife filed additional information on February 27, 2007, related to the movement of sucker species within the Link River, Keno reservoir, and at the J.C. Boyle fish ladder. Oregon Fish & Wildlife states that suckers were captured at the Keno dam fish ladder during the 1988 – 1991 trapping season, and that sucker passage was higher at Keno dam than it was at other traps that were monitored. They report that a total of 130 suckers were collected from the Keno ladder, including 6 Lost River, 3 shortnose, 99 Klamath smallscale, 6 largescale, and 22 unidentified juveniles. They report that 89 of the 130 suckers were collected in April 1989, when high flows occurred, and that two of the smallscale suckers had been previously tagged in J.C. Boyle reservoir. This information demonstrates that suckers are able to ascend the Keno fish ladder. The observation that movement occurred during high flows is likely related to increased flows triggering migration for this spring spawning species, but could also indicate that lower flows constrain passage through the Keno reach and access to the Keno ladder. Oregon Fish & Wildlife also summarized studies on the movement and distribution of suckers in the Link River and Keno reservoir conducted by Reclamation. These studies found that most upstream movements was associated with increasing spring flows or later in the summer when suckers moved upstream into Link River when water quality conditions in Keno reservoir became adverse. This information indicates that suckers are able to detect and avoid exposure to adverse water quality conditions in Keno reservoir. Based on the information filed by Oregon Fish & Wildlife, we conclude that the risk of sucker mortality in Keno reservoir may be limited by their ability to detect and emigrate from the area when water quality degrades. We also conclude that the Lost River and shortnose suckers are able to migrate upstream past Keno dam using the existing Keno ladder, at least during the high flow conditions that occur during the spring migration period.

Installing a lower gradient fish ladder at Keno dam also could improve passage for rainbow trout. However, monitoring conducted by Oregon Fish & Wildlife from 1988 to 1991 documents that rainbow trout are able to migrate through the existing Keno ladder. In its letter stating recommended terms and conditions, Oregon Fish & Wildlife state that the estimated number of rainbow trout that ascended the fish ladder alternated from about 200 fish in 1988 and 1990 to 60 fish in 1989 and 1991. In addition, rainbow trout residing in the Keno reach have access to suitable spawning habitat in Spencer Creek, and improving passage over Keno dam would provide little benefit to trout in the Keno reach because there is little known spawning or rearing habitat between the Keno and Link River dams.

Evaluating spillway passage at Keno dam and implementing any changes that are needed to improve downstream passage survival could improve the survival of listed suckers that emigrate downstream past Keno dam, and has the potential to improve the downstream passage survival of anadromous fish if they are restored upstream of Upper Klamath Lake. Even if fish screens were to be installed at the East Side and West Side facilities, and these were used to collect smolts for downstream transport, some fish would bypass the screens when river flows exceed the hydraulic capacity of East Side and West Side developments (1,450 cfs combined) and spills occur at Link River dam. These fish could then be subject to injury when the pass under the spillway gates at Keno dam, especially when the gates are held at narrow openings.

J.C. Boyle Development. PacifiCorp proposes to make minor modifications to the existing fish ladder at J.C. Boyle dam to improve passage, including increasing the bar spacing of the trashrack at the fishway exit pool to facilitate the passage of adult fish and adding a weir to the fishway entrance pool to decrease the height of the existing step. PacifiCorp also proposes to provide downstream fish passage at

J.C. Boyle by installing a barrier net, a fish collection device known as a gulper, and a bypass pipe that would deliver collected fish to the river downstream of the dam.

As previously described, Cal Fish & Game recommends that PacifiCorp construct volitional upstream fishways and volitional downstream passage facilities, and modify spillways to improve downstream passage survival at all project dams within 6 years. Cal Fish & Game and Oregon Fish & Wildlife both recommend that PacifiCorp install tailrace barriers at all project powerhouses within 8 years, and evaluate the hydraulic and biological performance of each facility.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp design and construct a new fish ladder at J.C. Boyle dam with a maximum gradient of 10 percent, two entrances, a screened auxiliary water system, and provisions for visual monitoring or a fish trap and counting system. Oregon Fish & Wildlife recommends that the ladder be constructed within 3 years, and the Hoopa Valley Tribe recommends that the ladder be constructed within 5 years.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp construct a downstream fish passage facility at J.C. Boyle dam that would operate year-round. Screens would divert fish to a sorting facility, where federally listed suckers would be removed and returned to the J.C. Boyle reservoir on a daily basis, with downstream migrants to be delayed no longer than 8 hours with the exception that fish captured at night would be released at night and fish captured in daylight would be released in daylight. Oregon Fish & Wildlife recommends that the facility be constructed within 4 years, and the Hoopa Valley Tribe recommends that the facility be constructed within 5 years.

NMFS and Interior prescribe that PacifiCorp construct a fish ladder to accommodate upstream passage for Chinook and coho salmon, steelhead, Pacific lamprey, and rainbow trout at J.C. Boyle dam within 4 years. The ladder would include a screened auxiliary water system that provides forebay water of the correct water quality and quantity to effectively attract fish. The ladder would have a maximum drop between pools of 0.5 feet and a slope not to exceed 10 percent. The ladder entrance would be located downstream of the fish screen bypass outfall and of the existing velocity barrier[78] below the existing fish ladder. NMFS and Interior also prescribe that a fish screen and bypass facility designed to meet NMFS screening criteria for the same species, and a tailrace barrier and guidance system be constructed, and that the spillway be modified to improve downstream passage within 4 years. In addition, NMFS and Interior prescribe that within 2 years, PacifiCorp should remove the potential fish barrier in the J.C. Boyle bypassed reach that was created by boulders which entered the stream channel during construction of the canal and road, about 2.5 miles upstream of the J.C. Boyle powerhouse.

PacifiCorp's April 25, 2006, alternative to the joint NMFS/Interior fishway prescription includes a provision to construct an adult trap and haul facility at Iron Gate dam that would be used to collect and transport adult anadromous fish to locations upstream of J.C. Boyle dam or at another location in the upper Klamath basin. If fisheries managers decide that self-sustaining runs of anadromous fish can be established, a juvenile trap and haul facility would be constructed at or above J.C. Boyle dam, and smolts would be transported past the project reservoirs. PacifiCorp's December 1, 2006, alternative fishway prescription includes provision of volitional downstream passage at all mainstem dams, volitional upstream passage at J.C. Boyle, and a new upstream migrant trap at Copco No. 2 dam.

Our Analysis

Provision of upstream passage for anadromous fish at J.C. Boyle dam as part of a future restoration effort could provide access to 4.7 miles of mainstem habitat in the Keno reach, about 15 miles

[78]The area considered to be a possible barrier to fish migration due to high water velocity is a short, high gradient section of the stream located just downstream of the entrance to the existing fish ladder.

of habitat in Spencer Creek, and about 355 miles of habitat tributaries to Upper Klamath Lake. As noted in our analysis of passage at Keno dam, however, the ability of re-introduced stocks to outmigrate through Upper Klamath Lake and Keno reservoir under present-day conditions is a critical uncertainty that must be addressed before a program to reintroduce anadromous fish upstream of Upper Klamath Lake is begun.

Although the Keno reach supports a good quality trout fishery, its ability to support production of anadromous salmonids is probably limited by the warm temperature and low DO content of water that enters the reach from Keno reservoir.[79] Aquatic habitat in Spencer Creek, however, is reported to be in good condition and has the potential to support coho salmon and other anadromous salmonids. PacifiCorp (2006a) reports that Spencer Creek contains abundant spawning habitat and excellent rearing conditions for coho salmon, providing more than three times the amount of rearing habitat, based on low-flow rearing area, than the combined area available in the tributaries between J.C. Boyle and Iron Gate dams (Jenny, Fall, and Shovel creeks). The existing fish ladder at J.C. Boyle dam does not meet current agency criteria, and its ability to pass anadromous fish species is unknown, because anadromous fish were blocked from the area when Copco No. 1 dam was built in 1918, before J.C. Boyle dam and fish ladder were constructed. However, based on the large numbers of trout that ascended the ladder in the first several years after its construction and the stronger swimming and leaping capability of adult anadromous salmonids compared to resident trout, we consider it likely that salmon and steelhead would be able to ascend the J.C. Boyle ladder.

Improving or replacing the existing fish ladder at J.C. Boyle dam would also allow rainbow trout from below J.C. Boyle dam to better migrate past the dam and access additional spawning habitat in Spencer Creek. However, we note that there is no direct evidence that the J.C. Boyle ladder does not currently provide effective passage for rainbow trout. The ladder successfully passed large numbers of trout in the first several years after J.C. Boyle dam was constructed. PacifiCorp has postulated that the advantage of upstream migration past J.C. Boyle dam may have been reduced when spawning areas near the confluence with Spencer Creek were inundated by the J.C. Boyle reservoir. It is also likely that ineffective screens at the J.C. Boyle intake caused substantial entrainment losses of downstream migrating trout, which would cause higher mortality rates among the migratory[80] component of the trout population. A third factor that may have contributed to reduced usage of the ladder is an increase in stream gradient that occurred downstream of the ladder since the dam was constructed. PacifiCorp has recently regraded this section and constructed resting pools to improve passage, but no monitoring data are available to document whether this measure has increased passage rates at the J.C. Boyle ladder.

Regardless of passage conditions at J.C. Boyle dam, trout residing between J.C. Boyle and Copco No. 1 dams have access to suitable spawning habitat in Shovel and Negro creeks and in the J.C. Boyle bypassed reach, and PacifiCorp has proposed and others recommend measures that should improve fry recruitment in both of these areas. These measures include augmenting gravel in the bypassed reach and screening or eliminating irrigation diversions in Shovel and Negro creeks. Although improving passage at the dam would benefit rainbow trout populations by increasing connectivity and genetic exchange, there is no indication that population levels of rainbow trout in either reach have declined due to a lack of access to appropriate spawning and rearing habitat, and both reaches support quality trout fisheries.

The sidecast boulders that NMFS/Interior prescribe to be removed from the J.C. Boyle bypassed reach form a barrier in the river that is likely to block or at least impede upstream passage of fish at existing minimum flows (figure 3-100), and the pool that is formed by this barrier likely impedes the

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[79]Rainbow trout in the upper Klamath River Basin are more tolerant of high water temperatures than most other salmonids, and conditions in the Keno reach during the summer months appear to be stressful even for these trout.

[80]Fluvial trout are trout that migrate within river and stream environments to access suitable spawning and rearing habitats.

transport of gravel to the lower half of the bypassed reach. Removing the barrier would increase the transport of gravel to the lower part of the reach, at least during the short-term, improving spawning habitat in that area. However, with implementation of a gravel or sediment augmentation program, as proposed by PacifiCorp and recommended by others, introduced sediment may initially collect in the pool, but eventually, if the pool fills, would be transported downstream of the sidecast barrier. Removing the sidecast barrier material also could facilitate passage of rainbow trout through the reach to access spawning and rearing habitat and the portion of the spring-water fed thermal refugia that are upstream of the sidecast barrier. If passage of anadromous fish to this section of the river is restored, removing the barrier would also improve access for anadromous fish to the thermal refuge in the spring-fed section of the bypassed reach and to upstream passage facilities at J.C. Boyle dam. Developing a site remediation plan in consultation with interested tribes, agencies, and non-governmental organizations (NGOs) prior to performing the work may identify opportunities for using sidecast materials to improve aquatic or riparian habitat, but the effects of any channel modifications on whitewater boater safety and recreation also would need to be considered.

Figure 3-100. Potential fish passage and gravel transport barrier formed by boulder sidecast material in the J.C. Boyle bypassed reach, about 2.5 miles upstream of the J.C. Boyle powerhouse. (Source: Staff)

Under the higher bypassed flow releases specified by the Bureau of Land Management and recommended by others, we consider it unlikely that the sidecast material would constitute a barrier to the passage of anadromous or resident fish species, which would reduce the potential benefits that would be achieved through sidecast barrier removal. We also note that removing the boulders would reduce the size and depth of the pool, which may reduce its potential value as a holding area for summer steelhead and spring Chinook salmon if they are restored to this reach. However, as we note in the previous paragraph, retention of the sidecast barrier, coupled with upstream sediment augmentation, could result in the pool filling with sediment and altering its value as salmonid habitat. Monitoring associated with sediment augmentation and resident and anadromous fish habitat use, discussed elsewhere, would enable assessments to be made regarding the benefits of retaining or removing the sidecast barrier under conditions specified in a new license.

The existing fish screen at the J.C. Boyle development does not meet current agency screening criteria, and based on the results of PacifiCorp's radio telemetry studies and collection of trout behind the screens when the canal is dewatered; it does not prevent fish from being entrained into the power canal. Installing an effective screening facility at J.C. Boyle dam could contribute to the restoration of anadromous fish to areas upstream of the dam by eliminating losses that would occur during turbine passage and by providing a means to collect smolts that could be used in fish passage studies or trucked and released downstream past the project. Trucking smolts to a location downstream of Iron Gate dam would bypass additional sources of mortality including predation, losses caused by poor water quality, and dam passage. It could also limit their exposure to disease pathogens if they are released downstream of the area of the highest pathogen densities that occurs in the first 50 miles downstream from Iron Gate dam, as discussed in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*. Even if smolt collection facilities were to be installed at East Side and West Side developments and smolts collected at Link River dam are transported downstream, constructing another facility at J.C. Boyle would allow smolts to be collected over a wider range of flows because of the greater hydraulic capacity at J.C. Boyle (3,000 cfs) compared to East Side and West Side developments (1,450 cfs combined). A collection facility at J.C. Boyle could also be used to collect smolts that are produced in Spencer Creek and in the Keno reach.

Installation of a fish screen at J.C. Boyle could also protect juvenile and adult rainbow trout and suckers from mortality that may be caused during turbine passage. However, as discussed previously, losses of larval suckers and juvenile lamprey from impingement may occur if velocities exceed their swimming ability, and to our knowledge, reliable criteria for safely screening these life stages have not yet been developed.

We do not consider installing a barrier net and gulper, as proposed by PacifiCorp, to be a viable option for providing downstream passage at J.C. Boyle development. Given the high primary productivity of project waters, algae growth during the summer would rapidly clog the net and lead to its damage or submergence, which would reduce its effectiveness in precluding fish from being entrained into the powerhouse intake.

Evaluating spillway passage and implementing changes needed to improve downstream passage survival could improve the survival of listed suckers that emigrate downstream from J.C. Boyle reservoir during spill periods, and has the potential to improve the downstream passage survival of anadromous fish if they are restored to areas upstream of J.C. Boyle dam. However, the potential benefit from improving the spillway at J.C. Boyle is limited by a low frequency of spills at that reservoir (see table 3-19). In addition, the benefit to anadromous fish could be further limited by low survival rates that may be experienced by fish that migrate in-river through the downstream developments. Even if fish passage facilities designed to meet current agency criteria were installed at Copco No. 2, Copco No. 1, and Iron Gate dams, cumulative losses during passage through these developments associated with poor water quality, predation, and injuries sustained during passage could be substantial.

Regarding Cal Fish & Game and Oregon Fish & Wildlife's recommendation to install tailrace barriers at all project powerhouses, and NMFS/Interior's prescription to install tailrace barriers at most developments including J.C. Boyle, we again conclude that the potential need for and benefits of installing tailrace barriers cannot be fully assessed at this time. We note that PacifiCorp, NMFS, and Interior have come to agreement on a stipulation that if volitional fish passage is prescribed at any of the project facilities, PacifiCorp would study the need for and design of spillway modifications and tailrace barriers for anadromous and native resident fish and that NMFS and FWS would base the need to implement spillway modifications and tailrace barriers on the results of the studies and other available information. This provision is included in NMFS and Interior's modified joint fishway prescription.

If volitional fishways are installed at any project dam, radio-telemetry studies could be used to determine the ability of upstream or downstream migrating fish to negotiate river reaches and passage facilities on their migration route to and from suitable spawning and rearing habitats. These studies could

be used to determine whether delayed migration occurs from attraction of fish to powerhouse outflows or whether or not any injuries are caused to fish that enter turbine draft tubes or pass over project dam spillways. If such delays or injuries are observed, construction of a tailrace barrier or spillway modifications may be warranted.

Copco Nos. 1 and 2 Developments. PacifiCorp has not proposed to implement any fish passage measures associated with Copco No. 1 or Copco No. 2 dams.

As previously described, Cal Fish & Game recommends that PacifiCorp construct volitional upstream fishways, volitional downstream passage facilities, and modify spillways to improve downstream passage survival at all project dams within 6 years. Cal Fish & Game and Oregon Fish & Wildlife both recommend that PacifiCorp install tailrace barriers at all project powerhouses within 8 years, and evaluate the hydraulic and biological performance of each facility.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp design and construct fish ladders at Copco No. 1 and Copco No. 2 dams that meet applicable criteria for Chinook and coho salmon, steelhead, Pacific lamprey, and rainbow trout and include provisions for visual monitoring or a fish trap and counting system. Oregon Fish & Wildlife recommends that the ladders be constructed within 6 years, and the Hoopa Valley Tribe recommends that the ladders be constructed within 5 years.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp construct downstream fish passage facilities at Copco No. 1 and Copco No. 2 dams that would operate year-round. The recommended facilities would include a trap for evaluating screen performance and accommodating long-term monitoring of downstream migrants. Oregon Fish & Wildlife recommends that the facilities be constructed within 6 years, and the Hoopa Valley Tribe recommends that the facility be constructed within 5 years.

FWS and NMFS prescribe that PacifiCorp construct fish ladders to accommodate upstream passage for Chinook and coho salmon, steelhead, Pacific lamprey and rainbow trout at Copco No. 1 and Copco No. 2 dams within 6 years. The ladders would include screened auxiliary water systems that provide forebay water of the correct water quality and quantity to effectively attract fish. The ladders would have a maximum drop between pools of 0.5 feet and a slope not to exceed 10 percent. FWS and NMFS also prescribe that fish screen and bypass facilities designed to meet NMFS screening criteria for the same species be constructed and that the spillways be modified at both dams to improve downstream passage within 6 years. FWS and NMFS also prescribe that tailrace barriers and guidance systems be constructed at both dams within 8 years. In addition, FWS and NMFS prescribe that PacifiCorp evaluate and develop a construction plan within 1 year to modify a bedrock sill in the Copco No. 2 bypassed reach to improve fish passage. The sill is located about 0.5 miles upstream of the Copco No. 2 powerhouse.

Our Analysis

Provision of upstream passage for anadromous fish at Copco No. 1 dam as part of a future restoration effort could provide access to 4.5 miles of reservoir habitat, 17.3 miles of mainstem riverine habitat in the J.C. Boyle peaking reach, about 3.3 miles of tributary habitat in Shovel Creek, 0.75 miles of tributary habitat in Long Pine Creek, and 4.3 miles of riverine habitat in the J.C. Boyle bypassed reach. Providing upstream passage over the Copco No. 2 dam would provide access to 0.3 miles of reservoir habitat between the Copco No. 1 and Copco No. 2 dams.

Providing fish passage over Copco No. 1 dam could provide anadromous fish with access to the substantial thermal refugium created by about 220 to 250 cfs of spring flow accretion in the J.C. Boyle bypassed reach. This refugium could be especially important for spring Chinook salmon and summer steelhead, which would benefit from the presence of cold pools to hold in during the summer months prior to spawning.

Although there currently are few rainbow trout in the Copco No. 2 bypassed reach that would benefit from implementing fish passage at the Copco No. 1 or Copco No. 2 dams, populations could increase if minimum flows are increased in the Copco No. 2 bypassed reach and effective passage is provided. However, because water temperatures in Copco reservoir are above optimal for salmonids for much of the year, we would not expect a substantial increase in the trout population, which limits the potential benefit of implementing fish passage for resident rainbow trout. Any adult trout present in the Copco No. 2 bypassed reach would likely need to pass both Copco dams to find spawning habitat or thermal refugia upstream of the reach. Moving in the downstream direction, however, would allow them to access spawning habitat and thermal refugia in tributaries to Iron Gate reservoir without needing to pass over any dams, although warm water temperatures may inhibit migration through the reservoir during the warmer months of the year.

Evaluating and possibly modifying the bedrock sill in the Copco No. 2 bypassed reach would help ensure that the bypassed reach is passable, which would be important if access to this reach is restored for anadromous fish. Based on the well-documented occurrence of anadromous fish upstream of the Copco dams (Hamilton et al., 2005), it is clear that the bypassed reach was passable to anadromous fish under the historical flow conditions prior to project construction. If this feature is determined to be a barrier at the minimum instream flows that would be implemented in a new license, modifying the sill to enable passage over the expected range of flows would improve passage conditions and the potential for restoration of anadromous fish to upstream habitats.

Installing fish screens at Copco No. 1 and Copco No. 2 dams could contribute to a future anadromous fish restoration effort by reducing losses that could occur during turbine passage. As previously noted, however, fish losses due to predation and adverse water quality conditions may limit the benefit of constructing downstream passage facilities. Screening facilities could also reduce mortality to any juvenile and adult shortnose and Lost River suckers that emigrate downstream past these developments, although mortality to larval suckers and juvenile lamprey may increase due to the potential for impingement on fish screens.

Evaluating spillway passage and implementing any changes needed to improve downstream passage survival could improve the survival of listed suckers that emigrate downstream, and has the potential to improve the downstream passage survival of anadromous fish if they are restored to areas upstream of Copco No. 1 and Copco No. 2 dams. However, the potential benefit from improving the spillways at the Copco dams is limited by a low frequency of spills (see table 3-19), and the benefit to anadromous fish could be further limited by low survival rates that may be experienced by fish that migrate in-river through Iron Gate reservoir. Even if fish passage facilities that meet current agency criteria were installed at all project dams, cumulative losses during passage associated with segments that have poor water quality, predation in project reservoirs, and injuries sustained during dam passage could be substantial.

Regarding Cal Fish & Game and Oregon Fish & Wildlife's recommendation to install tailrace barriers at all project powerhouses, and NMFS/Interior's prescription to install tailrace barriers at most developments including the Copco No. 1 and Copco No. 2 powerhouses, for the reasons that we discuss for the upstream project developments, we conclude that the potential need for and benefits of installing tailrace barriers cannot be fully assessed at this time.

Fall Creek Development. PacifiCorp proposes to construct fish ladders and screens at the Spring and Fall Creek diversions to provide passage for resident trout. The fish ladder at Spring Creek would be a timber or concrete pool- and weir-type ladder consisting of eight pools. The pools would be 4 feet by 5 feet with 0.5-foot vertical jumps. A fishway control structure consisting of a 24-inch diameter corrugated metal pipe culvert and manually operated slide gate would provide about 1 cfs of flow to the fishway. The fish ladder at Fall Creek would be a pool- and weir-type ladder consisting of six pools. The pools would be constructed from rock and include a 0.5-foot vertical jump for each pool. The existing

flashboards would be notched at the exit pool to permit a flow of 2.5 cfs to the fishway. The screens at both diversions would be diagonal-type screens meeting NMFS Southwest Region criteria for salmonid fry, including a maximum approach velocity of 0.4 fps, a sweeping velocity of 2 times the approach velocity, maximum screen openings of 1.75 mm, and a minimum open area of 27 percent of the total screen area. The bypass pipes would be 12 inches in diameter with 2.5 cfs of flow to each.

Cal Fish & Game recommends that PacifiCorp construct volitional upstream fishways and volitional downstream passage facilities, and modify spillways to improve downstream passage survival at all project dams within 6 years. Cal Fish & Game and Oregon Fish & Wildlife both recommend that PacifiCorp install tailrace barriers at all project powerhouses within 8 years, and evaluate the hydraulic and biological performance of each facility.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp design and construct fish ladders at the Spring and Fall creek diversions designed to pass juvenile and adult resident trout. Oregon Fish & Wildlife recommends that the ladder be constructed within 3 years, and the Hoopa Valley Tribe recommends that the ladder be constructed within 5 years.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp construct downstream fish passage facilities at the Spring and Fall creek diversions Oregon Fish & Wildlife recommends that the facility be constructed within 3 years, and the Hoopa Valley Tribe recommends that the facility be constructed within 5 years. Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that the facility include a trap for evaluating screen performance and accommodating long term monitoring of the downstream migrant population, including holding and sorting of fish by age and species. Downstream migrating fish would be delayed no more than 8 hours, with the exception that fish caught at night shall be released at night and fish caught during daylight shall be released during daylight.

NMFS and Interior prescribe that PacifiCorp construct a fish ladder to accommodate upstream passage for rainbow trout at the Spring Creek and Fall Creek diversions within 3 years. The ladders would have a maximum drop between pools of 0.5 feet and maximum slope not to exceed 10 percent. NMFS and Interior also prescribe that fish screen and bypass facilities designed to meet NMFS juvenile fish screen criteria be constructed at the Spring Creek and Fall Creek diversions within 3 years. NMFS and Interior also prescribe that a tailrace barrier and guidance system be installed within 5 years at the Fall Creek powerhouse to protect adult fish. In their modified prescription, the need for a tailrace barrier at the Fall Creek powerhouse would be determined based on site-specific studies.

Our Analysis

Fisheries sampling conducted by PacifiCorp in response to our information request (PacifiCorp, 2005a) indicates that Spring Creek supports a small population of rainbow trout, with few fish exceeding 8 inches in length. Electrofishing conducted above and below the diversion and in the diversion canal resulted in catch rates of 89, 14, and 100 fish per hour, respectively. Electrofishing in Fall Creek produced catch rates of 82 fish per hour upstream of the diversion and 188 fish per hour in the bypassed reach downstream of the diversion.

Fish that are diverted into the Fall Creek power canal have the potential to be entrained into the powerhouse and killed during passage through the turbines at the Fall Creek powerhouse. Fish that are carried by high flows or that emigrate over either diversion are likely prevented from returning upstream.

Although the installation of effective upstream and downstream passage at the Spring and Fall Creek diversions would improve connectivity between the populations upstream and downstream of the diversion and protect some trout from being killed during turbine passage, we concluded in the draft EIS that we could not quantify these losses based on the available information. We also noted that the fisheries in these streams were unlikely to support a substantive recreational fisheries, and we that the electrofishing data indicated that the trout populations in both streams were sustaining themselves.

As noted previously, subsequent to the section 10(j) meeting, Oregon Fish & Wildlife provided additional information on fisheries resources in Spring Creek and on the location and nature of privately-owned diversions located upstream and downstream of PacifiCorp's diversion on Spring Creek. They state that rainbow trout that inhabit portions of Spring Creek above the project diversion-works appear to be a unique population of trout, based on genetic (Buchanan et al., 1990) and disease resistance data (Buchanan et al., 1989). Oregon Fish & Wildlife also summarized the results of a 2000 fisheries survey conducted by Reclamation, which resulted in the collection of 23 trout in Shoat Springs Creek (at the headwaters of Spring Creek), 20 trout over about 400 feet of stream surveyed upstream of PacifiCorp's diversion, and three fish collected over 500 feet of stream sampled downstream of the diversion.

Although Oregon Fish & Wildlife did not provide any information on the genetic status of Fall Creek trout, the population in Fall Creek is isolated from the Klamath River by an impassable falls, and due to its proximity to Spring Creek and relative inaccessibility, it is likely that trout in Fall Creek have been similarly protected from exposure to adverse genetic effects from past stocking practices. The installation of intake screens and fish ladders at both diversions would help protect these populations from entrainment and to maintain connectivity of populations upstream and downstream of each diversion dam.

Given the low height of the diversion dams, it is unlikely that any fish would be injured during passage over the diversions, so we do not see any need to consider modifying the spillways at these diversions. For the same reasons given for the mainstem developments, the need for constructing a tailrace barrier can be evaluated most effectively if and when anadromous fish are restored to Fall Creek. Due to their weaker swimming ability, it is unlikely that the small resident trout that occur in Fall Creek could ascend into the turbine draft tube and be injured at the Fall Creek powerhouse.

Iron Gate Development. PacifiCorp does not propose to implement any fish passage measures associated with Iron Gate dam. As previously described, Cal Fish & Game recommends that PacifiCorp construct volitional upstream fishways and volitional downstream passage facilities, and modify spillways to improve downstream passage survival at all project dams within 6 years. Cal Fish & Game and Oregon Fish & Wildlife both recommend that PacifiCorp install tailrace barriers at all project powerhouses within 8 years, and evaluate the hydraulic and biological performance of each facility.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp design and construct a fish ladder at Iron Gate dam within 5 years that meets applicable criteria for Chinook and coho salmon, steelhead, Pacific lamprey, and rainbow trout and include provisions for visual monitoring or a fish trap and counting system. Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp construct a downstream fish passage facility at Iron Gate dam within 5 years that would operate year-round. The screen would include a trap for evaluating screen performance and accommodating long-term monitoring efforts.

In their preliminary and modified prescriptions, NMFS and Interior would require that PacifiCorp construct a fish ladder to accommodate upstream passage for Chinook and coho salmon, steelhead, Pacific lamprey and rainbow trout at Iron Gate dam within 5 years. The ladder would include a screened auxiliary water system that provides forebay water of the correct water quality and quantity to effectively attract fish. The ladder would have a maximum drop between pools of 0.5 feet and a slope not to exceed 10 percent. NMFS and Interior also prescribe a fish screen and bypass facility designed to meet NMFS screening criteria for the same species, and that the spillway be modified to improve downstream passage within 5 years.

PacifiCorp's April 25, 2006, alternative to the joint NMFS/Interior fishway prescription includes a provision to modify the existing Iron Gate Hatchery fish ladder's collection, sorting and holding facilities to facilitate the collection and transport of Chinook and coho salmon, steelhead, and Pacific lamprey to areas upstream of J.C. Boyle dam. Modifications would include constructing a hopper system to transfer fish from holding ponds to a transport truck and augmenting the existing sorting facility to enable detection and recording of electronic tag data and other identifiers. In its December 1, 2006,

alternative fishway prescriptions, PacifiCorp proposes to provide volitional downstream passage at all mainstem dams, including Iron Gate.

Our Analysis

Provision of upstream passage for anadromous fish at Iron Gate dam as part of a future restoration effort would provide access to 6.8 miles of reservoir habitat, 1.4 miles of mainstem riverine habitat in the Copco No. 2 bypassed reach, about 0.9 mile of tributary habitat in Fall Creek, and 1.1 miles of tributary habitat in Jenny Creek. The spawning potential for the Copco No. 2 bypassed reach appears to be relatively high based on a report by Coots and Wales (1952), who estimated that about 300 Chinook salmon spawned in the reach, and reported that, with a large number of spawners, a large portion of the available spawning habitat appeared to be unused. The flow in the bypassed reach at the time of their survey was estimated to be 8 cfs.

Installing a fish screen at Iron Gate dam could contribute to a future anadromous fish restoration effort by eliminating losses that would occur during turbine and spillway passage. However, even if fish passage facilities meeting current agency criteria were installed at all project dams, cumulative losses during passage associated with segments with poor water quality, predation in project reservoirs, and injuries sustained during dam passage could be substantial. If a decision was made to bypass these sources of mortality by collecting smolts at an upstream location and transporting them to a location downstream of Iron Gate dam, spillway improvements would provide no benefit to those fish that are transported, but they could benefit fish that bypass the smolt collection facility during spill periods.

Installing a screening facility or implementing spillway improvements could reduce mortality to any juvenile and adult shortnose and Lost River suckers that emigrate downstream past Iron Gate dam, although mortality to larval suckers and juvenile lamprey may increase due to screen impingement. Because there is no lake or reservoir habitat downstream of the dam that is suitable for Lost River or shortnose suckers, there would be little, if any, benefit to improving downstream passage survival for these species.

Regarding Cal Fish & Game and Oregon Fish & Wildlife's recommendation to install tailrace barriers at all project powerhouses, we have not seen any evidence in the record which indicates that a tailrace barrier is needed at Iron Gate dam. To our knowledge, there have not been any reports of fish injuries caused by fish entering the project draft tubes or of fish being delayed before they can find and enter the hatchery fish ladders, and we note that NMFS and Interior do not include a tailrace barrier at Iron Gate dam in their preliminary or modified fishway prescriptions.

Both of PacifiCorp's alternatives to the NMFS/Interior prescription include the collection of anadromous fish at Iron Gate dam, which would allow adult anadromous fish to be transported above J.C. Boyle dam or to habitat in the upper basin upstream of Link River dam (see the first part of this section for a discussion of the potential benefits of providing passage to and from habitat upstream of Link River dam). Fish could also be transported directly to upper basin tributaries during periods when water quality conditions are not suitable for migration through Upper Klamath Lake, or if a decision was made to focus restoration effort for a species on a single tributary. If coho salmon were transported to Spencer Creek, smolts produced from Spencer Creek could be collected in a smolt collection facility at the mouth of Spencer Creek or at J.C. Boyle dam. Spencer Creek appears to provide more coho salmon habitat than any other tributary upstream of Iron Gate dam.

Facility Design and Post-construction Evaluation

NMFS and Interior initially prescribe that PacifiCorp should design each upstream fish passage facility to pass migrants over a range of flows, bracketed by a designated high and low fish passage design flow. The low fish passage design flow would be the mean daily average stream discharge that is exceeded 95 percent of the time (based on at least 25 years of daily discharge data or an alternative

method approved by NMFS and FWS) during periods when migrating fish were historically present at the site. The high fish passage design flow would be the mean daily average stream discharge that is exceeded 5 percent of the time during periods when migrating fish were historically present at the site. Each fish ladder would be designed to provide a total attraction flow of at least 10 percent of the high fish passage design flow. For fishways at streams with annual mean flows greater than 1,000 cfs, PacifiCorp would determine an optimum attraction flow in consultation with NMFS and FWS. PacifiCorp would ensure that any reduction in attraction flow would not result in reduction in passage efficiency below standards established by NMFS and FWS during important fish migrations. PacifiCorp would test fishway performance, report testing results to NMFS and FWS, and implement appropriate modifications of attraction flow, but to no less than 5 percent of high fish passage design flow, if approved by Services.

NMFS' and Interior's modified prescriptions enable some relaxing of the above specifications based on site-specific studies. The designated high and low fish passage design flow and attraction flow would be in accordance with NMFS guidelines and criteria (NMFS, 2004) unless site-specific analysis, in consultation with NMFS and FWS, demonstrates a more suitable design passage flow or fish attraction flow that meets the objectives of safe, timely, and effective fish passage.

NMFS and Interior prescribe that PacifiCorp develop detailed design, construction, evaluation, and monitoring plans for review and approval by NMFS and FWS prior to construction. Facilities would be constructed according to NMFS guidelines for the design of fish screens, fishways, and other fishway structures. All designs would be reviewed by an agency fisheries technical committee, and agency consultation would be required during the conceptual level design. NMFS and FWS would approve conceptual design prior to feasibility and final level design, and PacifiCorp would allow at least 90 days for review and approval. Plans would include provisions for stocking critical spare parts and equipment to provide timely repairs of critical system components. Downstream fishways (screens, bypasses, and spillway modifications) would be completed prior to the completion of upstream fishways. After approval by NMFS and FWS, final designs would be filed with the Commission.

NMFS and Interior prescribe that prior to the completion of construction of new fishways, PacifiCorp, in consultation with a fisheries technical subcommittee, would develop post-construction monitoring and evaluation plans to assess the effectiveness of each fishway, spillway, and tailrace barrier. Plans would include hydraulic, water quality, and biological evaluations using electronic tags of similar technology to detect and record fish passage and assess the performance of the fishway. PacifiCorp would provide a report on the monitoring and evaluation annually for the term of the license, including estimates of the numbers of fish passed by species on a daily basis (including spring and fall-run Chinook salmon, coho salmon, steelhead, Pacific lamprey, Lost River and shortnose suckers, and rainbow trout); sampling of fish size and age class on a daily basis; records of daily observations by a qualified fisheries biologist on the physical condition of fish using the fishways; and a continuous record of DO and water temperature at locations in the fishways determined by NMFS and FWS, and in front of and adjacent to the entrances and exits of the fishways. Evaluation plans would be submitted to NMFS and FWS within 6 months of the date when final designs for fishway construction are approved by Services. At least 60 days would be given for NMFS and FWS to review evaluation plans. PacifiCorp would fund plan implementation and any operational or physical changes necessary for effective fish passage.

NMFS and Interior prescribe that PacifiCorp, in consultation with a fisheries technical subcommittee, prepare a fishway evaluation and modification plan for each fishway, spillway, and tailrace barrier. An outline for the plan would be provided to NMFS and FWS no later than 1 year from license issuance, and complete plans would be submitted to NMFS and FWS no later than 18 months from license issuance. Each plan would include: (1) a quantified program to meet NMFS and FWS' fish passage goals, objectives, and strategies; (2) the Services' criteria by which to measure progress towards fisheries management goals; (3) procedures for redirecting effort; (4) a schedule for implementation of activities; (5) a monitoring plan to evaluate progress towards and achievement of Services' goals and objectives; and (6) a format for an annual report and work plan. An annual report detailing work under

this plan for previous year would be submitted by February 1. By December 1 of every year, PacifiCorp would submit a proposed work plan for the upcoming year.

Our Analysis

Development of the design of any fish passage facility would benefit from close cooperation with NMFS and other agencies to ensure that the design takes advantage of available expertise and that the facilities are as effective as possible. Given their expertise in this area, we agree that close consultation with NMFS and FWS during design development and review for any fishways that are constructed would be beneficial. We do not concur with NMFS and Interior, however, that it is necessarily appropriate to construct downstream passage facilities before upstream passage is provided. We generally concur with the approach that PacifiCorp lays out in its alternative prescription where upstream passage of adult fish would be provided to assess the capacity of upstream habitat and to address uncertainties regarding losses that may occur in migration corridors before investing in a mainstem smolt collection facility. This may prevent the construction of downstream passage facilities that would never be needed.

Developing and implementing post-construction monitoring and evaluation plans to assess the effectiveness of any fish passage facilities that are constructed, as prescribed by NMFS and Interior, is appropriate for ensuring that facilities function as intended, and that any modifications needed to provide adequate performance can be made. We agree that the elements that NMFS and Interior specify are generally appropriate for use in a post-construction monitoring and evaluation plan, but conclude that the scope of the evaluation plan for a specific facility should be developed in consultation with the agencies. We are less sure of the need and basis for the prescribed evaluation and modification plan, which would require PacifiCorp to evaluate the facility's conformance with NMFS and FWS fish passage goals, objectives, and strategies. We concur that it is appropriate to define performance criteria for the fish passage facility, but conformance with the Service's fish passage goals, objectives, and strategies may involve factors that are beyond PacifiCorp's control, such as the numbers of adult fish that return from the ocean, or losses during migration that are associated with water quality conditions that may result from upstream land use practices.

We concur with NMFS and Interior that it is appropriate to design upstream fish passage facilities to function properly over a typical range of operating flows. We do not see any basis, however, for the requirement in the preliminary prescription that each fish ladder be designed to pass 5 to 10 percent of the high design flow to create sufficient flows to attract and pass targeted species at each fishway. If PacifiCorp can provide a sound basis for using a lower amount of attraction flow and demonstrate via post-construction evaluation studies that the attraction flow is sufficient to attract fish to enter and ascend the facility, the lower attraction flow volumes should be allowed. NMFS' and Interior's modified prescription addresses our concern and allows PacifiCorp the option of conducting site-specific studies to assess whether or not alternative passage and attraction flows might also enable safe, timely, and effective fish passage.

Operation and Maintenance

Oregon Fish & Wildlife recommends that PacifiCorp develop and implement written standard operation and maintenance procedures for upstream passage and downstream passage facilities that include procedures for prior notification and coordination with agencies on maintenance scheduling or emergencies that may affect functioning of fish passage facilities. The procedures would also include provisions for daily inspections during peak seasonal migrations of major species (rainbow trout, suckers, and anadromous fish) and weekly inspections during non-peak migrations. Similarly, NMFS and Interior prescribe that PacifiCorp, in consultation with agencies, develop a fishway operation, inspection, and maintenance plan describing these planned activities and contingencies for each fish passage facility.

Oregon Fish & Wildlife also recommends that PacifiCorp notify agencies at least 2 weeks in advance of any contemplated maintenance shutdowns of upstream passage or downstream passage facilities that may result in dewatered waterways or reduced flows that may result in stress or mortality to fish. In addition, Oregon Fish & Wildlife also recommends that PacifiCorp salvage live fish from the waterways during maintenance shutdowns and consult with the agencies to determine where salvaged fish would be relocated.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend and NMFS and Interior prescribe that PacifiCorp allow agencies and tribes, including Oregon Fish & Wildlife and the Hoopa Valley Tribe, access to, through, and across project lands and works for the purpose of inspecting fishway facilities and records, including monitoring data, to monitor compliance with fishway requirements that may be included in a new license.

NMFS and Interior prescribe that PacifiCorp keep all fishways in proper order, clear of trash, sediment, logs, debris, and other material that would hinder passage or create a personnel safety hazard, and to perform maintenance well in advance of critical migratory periods. If any fishway becomes seriously damaged or inoperable, PacifiCorp would notify NMFS and FWS within 48 hours and take timely remedial action in a manner satisfactory to NMFS and FWS.

Our Analysis

Developing an operations and maintenance plan in consultation with the fisheries management agencies and tribes, for any fishways or trap and haul facilities that are constructed, would help ensure that the facilities function as intended. We would expect that provisions for notifying agencies of any planned maintenance procedures that would involve dewatering of any facilities and for notifying the agencies of any major operational problems would be part of the operations and maintenance plan.

3.3.3.2.3 Disease Management

As we discuss in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, disease problems in recent years have contributed to substantial losses of juvenile and adult salmon and steelhead in the migratory corridor downstream of Iron Gate dam. In 2002, a combination of factors including low flows, high water temperatures, and a high density of fish in the river resulted in an outbreak of *Ichthyophthirius multifi* (Ich) and *Flavobacterium columnare* (columnaris disease) that resulted in the death of more than 33,000 adult salmon and steelhead, most of which were fall Chinook salmon, in the lower 36 miles of the river (Cal Fish & Game, 2004). Although this fish kill had a severe adverse effect on the number of fall Chinook salmon that survived to spawn in 2002, chronic losses of juvenile salmon from disease appear to pose an even greater threat to the health of the fall Chinook salmon population. Nichols and Foott (2005) estimated that 45 percent of the juvenile fall Chinook salmon that outmigrated in 2004 were infected with *C. shasta* and 94 percent of the population was infected with *P. minibicornis*. They concluded that the high incidence of fish infected with both pathogens suggests that the majority of the *C. shasta* infected juvenile Chinook salmon would not survive. Monitoring results in 2005 reported by Nichols (2005) indicate that infection rates of juvenile fall Chinook salmon with *C. shasta* increased to levels that exceeded 70 percent by late April, and infection rates for *P. minibicornis* ranged between 94 and 100 percent from late April through at least mid-May.[81] True (memo from K. True, FWS, to the Klamath Fish Health Distribution List, dated June 8, 2006, accessed at http://ncncr-isb.dfg.ca.gov/KFP/uploads/2006%20pathogen%20monitoring%2009-15.doc on October 30, 2007) reports that infection rates of juvenile fall Chinook salmon in 2006 have remained at low levels through

[81]Nichols (2005) did not report the results of monitoring conducted after mid-May 2005, which were pending at the time that the memo was prepared.

the month of June for both *C. shasta* and *P. minibicornis*. The lower infection rates reported in 2006 to date may be related to substantially higher flows compared to 2004 and 2005.

PacifiCorp does not propose any measures related to management of fish diseases in the lower Klamath River. In its alternative to the NMFS/Interior fishway prescription, PacifiCorp includes monitoring of resident and anadromous fish populations for the presence of *F. columnare*, *C. shasta* and *P. minibicornis*, and testing juvenile rainbow trout for Infectious Hematopoietic Necrosis (IHN). PacifiCorp would also undertake sentinel rainbow trout studies[82] to detect whether disease load and severity increases if anadromous fish are reintroduced into the upper Klamath basin.

Recommendations made by the agencies related to disease management are summarized in table 3-72. Oregon Fish & Wildlife, Cal Fish & Game, NMFS and FWS recommend that PacifiCorp develop juvenile and adult disease risk monitoring and management plans that would be implemented within 2 years after development and agency approval. The plans would include: (1) studies to determine key factors controlling disease risk and pathogen abundance; (2) assessment of benefits through restoration of geomorphic processes and management of flows and water quality to minimize disease risk; (3) conducting test flows of varying extent and magnitude to determine sufficient mobilization of the bed that results in scour of algae mats and then subsequent testing of the abundance of *C. shasta* and *P. minibicornis* and their polychaete intermediate host; and (4) steps to minimize disease risk to reintroduced anadromous species above Iron Gate dam, to resident species, and to fish production at Iron Gate Hatchery. NMFS also recommends that the plans include an assessment of measures for controlling, managing or removing pathogens, vectors, and hosts or their habitats to minimize disease risk. The Forest Service makes a similar recommendation to continue assessment of the habitat requirements of the polychaete secondary host for *C. shasta* and *P. minibicornis*, determine other dynamics which influence these diseases, determine how project operations can be altered to reduce disease incidence, and develop adaptive management measures. Siskiyou County recommends that PacifiCorp fund studies leading to the reduction or elimination of disease problems that currently exist downstream of Iron Gate dam.

Oregon Fish & Wildlife, Cal Fish & Game, NMFS, and FWS also recommend that PacifiCorp develop an emergency response pulse flow plan to temporarily enhance flows, using up to 52,000 acre-feet of storage[83] in Copco and Iron Gate reservoirs when an interagency fish health assessment team determines that enhanced flows would likely decrease the adverse affects of an impending juvenile or adult fish die-off. PacifiCorp would also provide reports summarizing the successes and failures of such attempts and recommendations for future enhanced flow management.

Although the tribes and non-governmental organizations did not provide any similar recommendations for disease management, reducing the incidence of losses from fish disease is a central element of their rationale for recommending removal of the mainstem dams. The Resighini Rancheria and Institute for Fisheries Resources/Pacific Coast Federation of Fishermen's Associations recommend full decommissioning of the project, which we interpret to mean removal of all project dams. The Quartz Valley Indian Community, Klamath Tribes, Karuk Tribes, Yurok Tribe, Conservation Groups, and PFMC all recommend removal of the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams.

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[82]Studies in which trout are held alive in cages placed in the river for a pre-determined period of time and then rates of infection are determined during a post-exposure holding period.

[83]In their response to AIR AR-1(a), PacifiCorp (2005) indicates that the maximum drawdown that would allow continued turbine operation is elevation 2,601 ft at Copco reservoir and elevation 2,319 ft at Iron Gate reservoir, which indicates that the active storage at these reservoirs are 5,713 and 7,238 acre-feet, respectively. This amounts to a total active storage in the two reservoirs of 12,951 acre-feet as opposed to the 52,000 acre-feet stated by NMFS.

Table 3-72. Disease management recommendations. (Source: Staff)

Category	Oregon Fish & Wildlife	Cal Fish & Game	NMFS	FWS	Forest Service
Juvenile fish disease risk monitoring and management	Develop and implement a juvenile fish disease risk monitoring and management plan to reduce disease risk for juvenile anadromous salmonids in the Klamath River. Conduct studies to determine key factors controlling disease risk and pathogen abundance and, if appropriate, assess the benefits of using geomorphic processes, management of flows, and water quality to minimize disease risk. Implement the plan within 2 years of development and agency approval.	Essentially the same as Oregon Fish & Wildlife's recommendation 14A, but with less detail. Like Oregon Fish & Wildlife, no time frame is given for developing the plan, but it would be implemented within 2 years of plan development.	Same as Oregon Fish & Wildlife, but plan would include recommended measures for controlling, managing, or removing pathogens, hosts, and vectors; and assessment of the benefits through restoration using physical removal or treatment of pathogens, vectors, hosts, or their habitats.	Essentially the same as Oregon Fish & Wildlife's and NMFS recommendations.	Continue to assess habitat requirements for the polychaete secondary host and determine other dynamics that influence *C. shasta* and *P. minibicornis*. Determine how project operations can be altered to minimize polychaete habitat and reduce disease incidence and develop adaptive management measures.
Adult fish disease risk monitoring and management	Develop and implement an adult fish disease risk monitoring and management plan to reduce disease risk for adult anadromous salmonids below Iron Gate dam. Include recommendations for managing flows, geomorphic processes, and water quality to minimize disease risk, and steps to minimize disease risk to reintroduced anadromous species and resident species above Iron Gate dam. Include studies to assess the role of seasonal	Essentially the same as Oregon Fish & Wildlife's recommendation. Cal Fish & Game does not provide as much detail as Oregon Fish & Wildlife. Like Oregon Fish & Wildlife, no time frame is given for developing the plan, but it would be implemented within 2 years of plan development.	Same as Oregon Fish & Wildlife, but plan would include an assessment of the benefits through restoration using physical removal or treatment of pathogens, vectors, hosts or their habitats to minimize disease risk.	Essentially an abbreviated version of Oregon Fish & Wildlife's and NMFS recommendations	

Category	Oregon Fish & Wildlife	Cal Fish & Game	NMFS	FWS	Forest Service
	flow reductions in increasing habitat and pulse flows in decreasing habitat for the intermediate host of *C. shasta,* test flows of varying extent and magnitude to determine sufficient mobilization of the bed to scour algae mats and subsequent testing of polychaete and pathogen abundance. Implement plan within 2 years of development and agency approval.				
Emergency response pulse flow plan	Develop a plan to provide temporary enhanced flows on an emergency basis using the estimated active storage of Iron Gate and Copco reservoirs of 52,000 acre-feet. These flows would be provided when an interagency fish health assessment team determines that enhanced flows would likely decrease the effects of an impending juvenile or adult fish die-off. Provide reports summarizing the successes and failures of such attempts and recommendations for future enhanced flow management.	Essentially the same as Oregon Fish & Wildlife. Like Oregon Fish & Wildlife, no time frame is given for developing the plan, but it would be implemented within 2 years of plan development.	Same as Oregon Fish & Wildlife recommendation	Same as Oregon Fish & Wildlife's and NMFS recommendations	

Our Analysis

The very high infection rates of *C. shasta* and *P. minibicornis* observed in juvenile fall Chinook salmon migrants in 2004 and 2005, and mortality rates observed during juvenile migration monitoring, indicate that losses of juvenile migrants may be having a substantial effect on fall Chinook salmon

populations in the Klamath basin.[84] Migrant sampling conducted by FWS in 2004 indicate that high observed infection rates were associated with high rates of immediate mortality in juvenile fall Chinook salmon (figure 3-101). Monitoring data from both years indicate that both infection and mortality rates tend to increase rapidly with increasing water temperatures, which is consistent with high rates of mortality observed during periods of sustained high water temperatures observed during screw trap sampling conducted in the Klamath River near Big Bar (RM 50) in 1997 and 2000 by Scheiff et al. (2001). Given the general trend of increasing water temperatures in the basin over the last several decades reported by Bartholow (2005), there is strong potential that disease-related mortality of both juvenile and adult migrants could increase in the future.

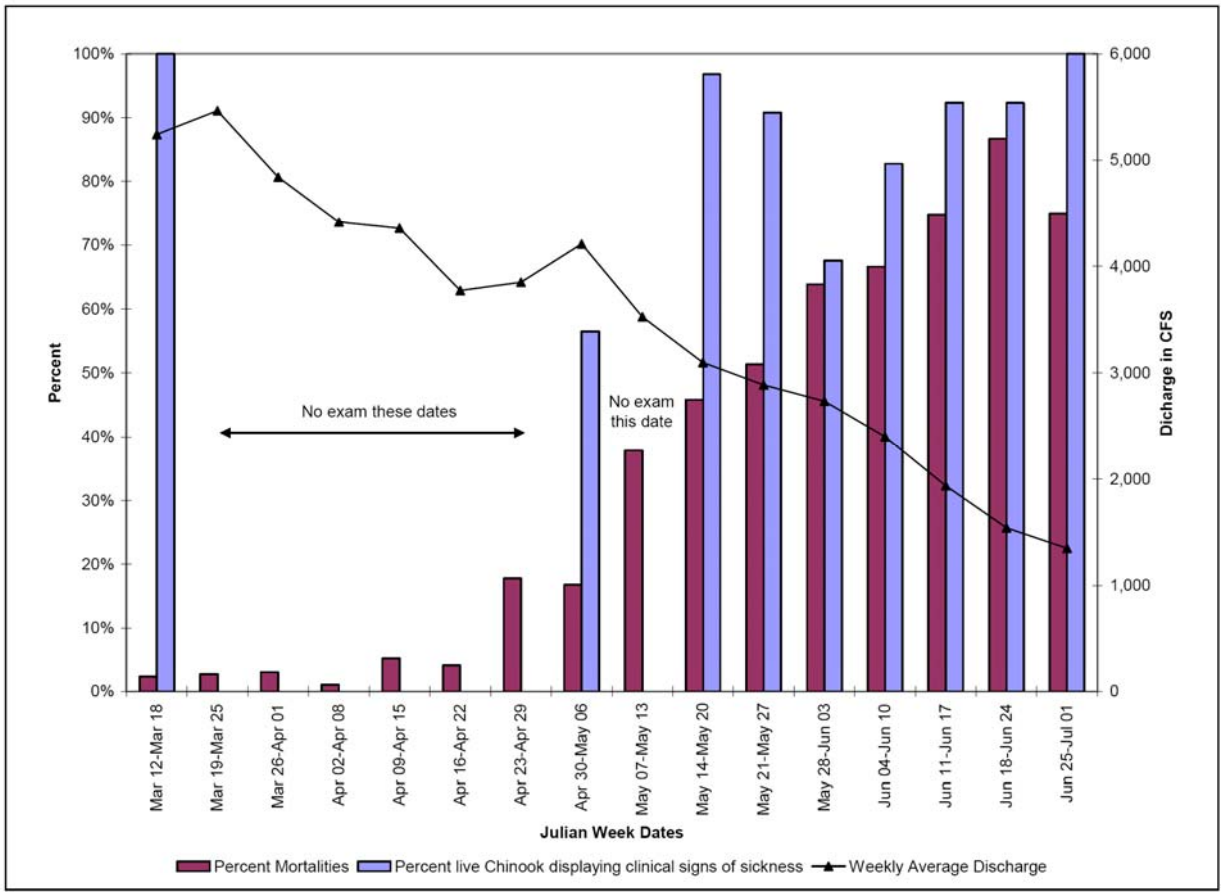

Figure 3-101. Percent of weekly frame-trap catch of Chinook salmon that were dead, percent of remaining live Chinook salmon examined that exhibited outward clinical signs of disease, and weekly average discharge at the Kinsman trap site (RM 146) on the Klamath River near the mouth of the Scott River in 2004. (Source: KFHAT, 2005)

Disease losses in the mainstem of the Klamath River may affect runs of fall Chinook salmon in the entire Klamath basin, including its major tributaries. As we discussed in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, Nichols et al. (2003) found that 19 percent of marked fall Chinook salmon smolts outmigrating from the Trinity River became infected with *C. shasta* as they migrated

[84]In their assessment of juvenile disease losses that occurred in 2004, Nichols and Foott (2004) concluded that the effective number of adult salmon lost to *C. Shasta* as juveniles could rival the 33,000+ adult salmon that were lost in the 2002 Klamath River fish dieoff.

through the lower most 44 miles of the Klamath River. Cal Fish & Game (2004a) reported that losses of adult Trinity River fall Chinook salmon during the 2002 adult fish kill may have exceeded 20,000 fish.

Although we note that assessing the population effects of mortality in the freshwater environment is complicated by substantial variations in ocean survival, factors that exert substantial influences on survival rates in either environment are likely to affect the number of adult salmon that contribute to ocean fisheries or that return to the Klamath River. We conclude that disease losses in the lower Klamath River migratory corridor have most likely contributed to recent declines in the number of fall Chinook salmon, and have the potential to cause fall Chinook salmon populations in the basin to decline further, unless measures can be found to reduce losses from disease, particularly in warm years and when low flows occur. Efforts to restore passage of anadromous fish to any areas upstream of the project may provide little or no benefit if disease problems in the Klamath River downstream of the project are not effectively addressed.

The Klamath Hydroelectric Project has likely contributed to conditions that foster disease losses in the lower Klamath River by (1) increasing the density of spawning adult fall Chinook salmon downstream of Iron Gate dam; (2) promoting the development of attached algae beds that provide favorable habitat for the polychaete alternate host for *C. shasta* and *P. minibicornis*; and (3) contributing to water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease. The water quality conditions that may increase stress levels include: (1) increased water temperatures in the late summer and fall; (2) swings in DO, pH, and ammonia levels associated with algal blooms in project reservoirs; and (3) effects of exposure to elevated levels of microcystin produced from *Microcystis* blooms in project reservoirs, which may also result in direct mortality. The project may also reduce fish stress during the spring by delaying the increase in water temperature to stressful levels during the start of the smolt outmigration period. We evaluate these factors in the following section, followed by a discussion of possible approaches for reducing the incidence of fish diseases in the Klamath River downstream of Iron Gate dam.

The lack of fish passage at the project and natural spawning by stray fish produced at the Iron Gate Hatchery has likely contributed to a high density of fall Chinook salmon spawning in the 13-mile long section of the river between Iron Gate dam and the Shasta River and in Bogus Creek. During spawning surveys conducted between 1993 and 2002, an average of 51.9 percent of all mainstem redds were observed in this reach, which constitutes 15.4 percent of the 84.4 miles of river that were surveyed (see table 3-49). Sampling conducted in 2005 indicates that two sites in this reach had a high prevalence of *C. shasta* infection in its polychaete alternate host, which Bartholomew and Stocking (2006, personal communication cited by Resighini Rancheria, 2006), consider to most likely be the result of proximity to spawning areas. Resighini Rancheria (2006) state that returning adult salmon can become infected with *C. shasta* as they move upriver, and that when they spawn and die, the *C. shasta* myxospores contained inside of them are released and can infect polychaetes. The incidence of disease and mortality of juvenile fall Chinook salmon collected downstream of this reach can reach very high levels, as indicated in figure 3-101. Although information on the effect of these diseases on the federally listed coho salmon is limited, recent information, summarized in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, indicates that coho salmon may be somewhat more susceptible to Ceratomyxosis than fall Chinook salmon when they are exposed to *C. Shasta* at comparable water temperatures. Mortality of coho salmon smolts and other species that outmigrate as yearlings (steelhead and spring Chinook salmon) from the disease may be reduced by their tendency to outmigrate earlier than fall Chinook salmon smolts, when water temperatures are lower. However, we conclude that it is likely that increasing incidence of the disease in the fall Chinook salmon population would result in increased infection rates of other species of resident and anadromous salmonids.

The incidence of *C. shasta* and *P. minibicornis* in this reach may be further increased by the presence of *Cladophora*, a genus of algae that provides a favorable habitat for *M. speciosa*, a species of polychaete that has been identified as an alternate host for both of these disease pathogens. As discussed

in section 3.3.2.2.2, *Water Quality*, *Cladophora* spp. tend to proliferate in reaches downstream of nutrient sources, and we conclude in that section that its abundance downstream of Iron Gate dam is likely associated with seasonal releases of nutrients associated with blooms of the nitrogen-fixing blue-green algae, *Aphanizomenon flos-aquae*, in Upper Klamath Lake and in Keno, Copco No. 1, and Iron Gate reservoirs. As we discuss in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, patches of *Cladophora* provide a favorable habitat for *M. speciosa*, because it is sufficiently porous to collect fine benthic organic matter (including phytoplankton produced in the project reservoirs), providing a food source for the polychaete, as well as a refuge from scouring during high flow events.

In section 3.3.2.2.2, *Water Quality*, we conclude that algae blooms that occur in the project reservoirs during the spring and summer also contribute to wide fluctuations in DO levels, pH, and ammonia in the mainstem Klamath River downstream of Iron Gate dam. These conditions, combined with water temperatures that are generally in the stressful to severely stressful range for salmonids from June through September, as well as toxins produced by blooms of *Microcystis* algae, likely contribute to a high level of stress that increases susceptibility to disease, and may lead to direct mortality in extreme situations. As indicated in tables 3-69 through 3-71, water temperature and DO levels predicted by PacifiCorp's water quality model indicate that stressful conditions for juvenile fall Chinook salmon generally occur starting in late May, which coincides with the season when increased collections of diseased and dead juvenile fall Chinook salmon were observed during screw-trap monitoring in 2004 (figure 3-101). In other years, fish kills have been reported later in the summer, coinciding with periods when water temperatures exceeded 20°C. Scheiff (2001) reported that, during screw trap sampling conducted at Big Bar in 2000, dead fish were observed in late June and early July, when an estimated 100,000 to 300,000 juvenile Chinook salmon and steelhead died in the mainstem Klamath River, and that a similar fish kill occurred in August of 1997 that included a wider range of non-salmonid species. Figure 3-102 shows water temperatures and river flows observed in those years.

PacifiCorp's water quality modeling also indicates that the seasonal temperature shift caused by the project reservoirs serves to lower water temperatures in the spring through most of July in low flow years, but increases water temperatures below Iron Gate dam starting in late July (figure 3-50). This shift likely reduces vulnerability to disease for early-migrating smolts, but increases stress and disease for the later migrating fish. The magnitude of the temperature shift is likely less in higher water years, and the transition from a net cooling to a net warming effect likely occurs earlier than occurs in low water years.

Development of an effective disease management plan may be essential to prevent further decline of the populations of Klamath fall Chinook and coho salmon. In the draft EIS, we recommended that PacifiCorp be required to develop a disease management plan, and we suggested 12 measures that might be considered. Comments on the draft EIS did not endorse any of the 12 proposed measures, and many parties commented that the plan was not specific enough, and would provide little assurance of the effectiveness of the plan. We reconsidered our recommended approach and developed a new plan that integrates the assessment of potential disease control measures with an aggressive approach to better understand the causes of recent increases in losses of juvenile fall Chinook salmon and its relationship with project effects on water quality conditions downstream of Iron Gate dam. The program is integrated with experiments designed to address critical uncertainties associated with an equally aggressive program to evaluate alternative approaches and implementing the restoration of anadromous fish to habitat upstream of Iron Gate dam. We present this integrated approach, including a specific timeline for implementation, in section 3.3.3.2.5, *Anadromous Fish Restoration*.

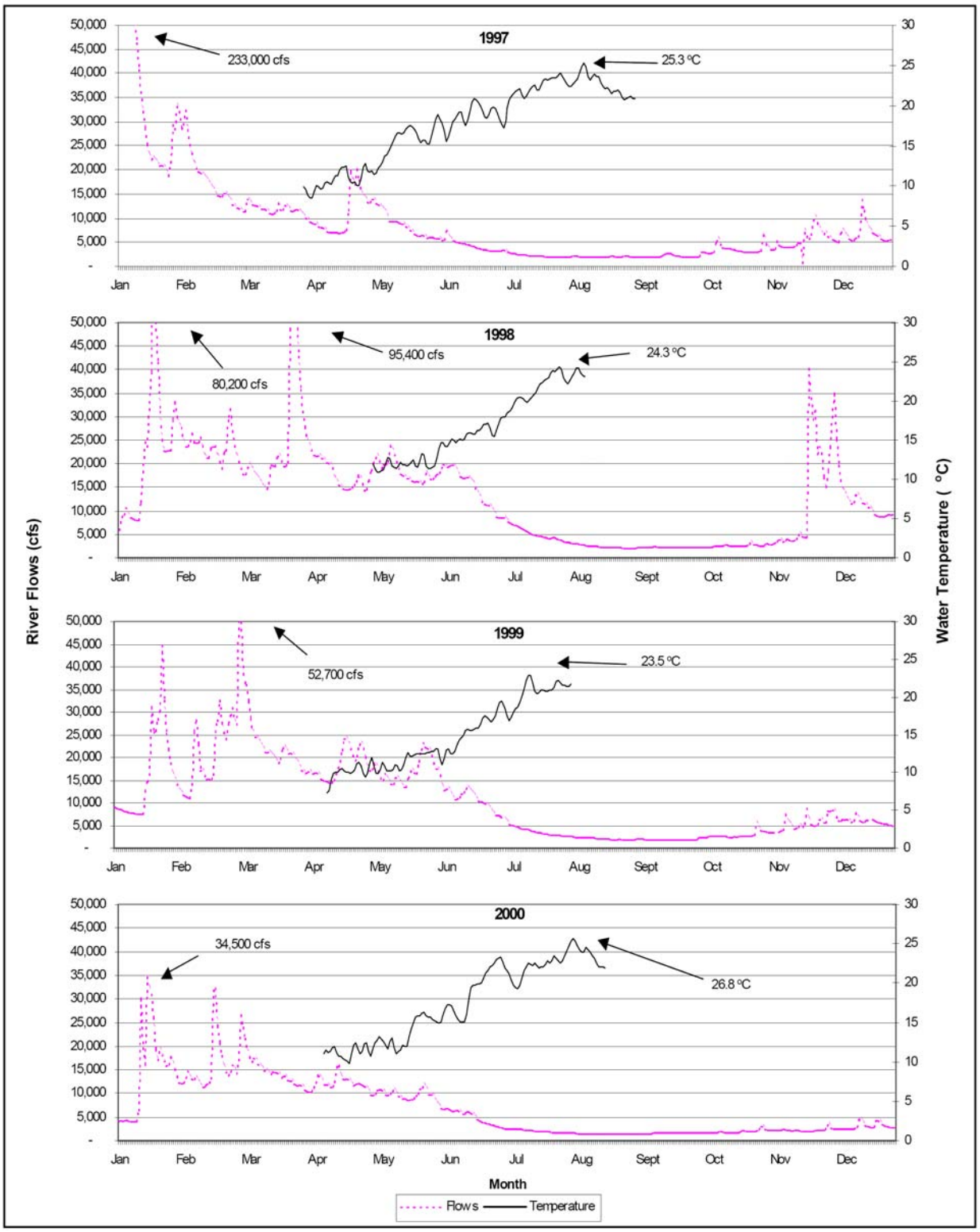

Figure 3-102. Mean daily flow (cfs) at Orleans and mean daily river temperature (°C) at the Big Bar screw trap sampling site (RM 49.7), 1997-2000. (Source: Scheiff, 2001)

Developing the plan in close consultation with other stakeholders including those that are involved in disease and water quality monitoring and habitat restoration efforts would help to ensure that the plan can be refined and executed as efficiently and effectively as possible. As we conclude in section 3.3.3.2.5, *Anadromous Fish Restoration*, consultation with all interested agencies, tribes, and NGOs would be appropriate, given their shared interest in anadromous fish conservation and restoration.

3.3.3.2.4 Dam Removal or Decommissioning

Many stakeholders recommend the removal of most or all of the project dams with the goals of restoring passage of anadromous fish to upstream habitats, improving water quality conditions in and below the project, and alleviating conditions that contribute to disease-related mortality of juvenile and adult anadromous fish in the mainstem Klamath River below the project. Although PacifiCorp does not propose to remove any of the project dams, it does propose to decommission the East Side and West Side facilities to eliminate entrainment of federally listed suckers.

The Resighini Rancheria and the Institute for Fisheries Resources/Pacific Coast Federation of Fishermen's Associations recommend full decommissioning of the project, which we interpret to mean removal of all project dams. The Quartz Valley Indian Community, Klamath Tribes, Karuk Tribe), Yurok Tribe, NMFS, Conservation Groups, and PFMC all recommend removal of the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams.

Oregon Fish & Wildlife and Cal Fish & Game recommend that, if it proves not to be feasible to provide safe, timely, and effective upstream or downstream fish passage at any project facility, PacifiCorp prepare a decommissioning proposal for the subject facility in consultation with applicable state, federal, and tribal stakeholders.

Oregon Fish & Wildlife also recommends that PacifiCorp prepare a decommissioning plan for East Side and West Side developments that includes permanent sealing of the intakes and fish-proofing of potential areas of mortality or injury within 1 year of license issuance and implement the plan within 1 year of Commission approval. NMFS and FWS recommend that PacifiCorp develop a decommissioning plan within 1 year that identifies optimal periods of the year to avoid impacts on fish and wildlife from decommissioning activities. NMFS also recommends that decommissioning be implemented within 3 years of license issuance, with results monitored to determine future needs.

NMFS recommends that PacifiCorp establish and maintain a decommissioning fund to finance potential future decommissioning of the project, as provided for in the Commission's policy statement on decommissioning. The Hoopa Valley Tribe recommends that, in the event that PacifiCorp proposes to abandon any of the project facilities, PacifiCorp would remove or modify project facilities and restore pre-project conditions in any manner reasonably required by federal and state agencies to maintain fish and wildlife production in the project-affected area.

The Yurok Tribe recommends the Commission enlist the help of stakeholders, agencies, and outside experts to decide the future fate of Iron Gate Hatchery and other potential artificial propagation programs in the event of decommissioning, and determine how the hatchery could best contribute toward restoration efforts in the Klamath Basin.

Our Analysis

We do not consider the NMFS recommendation that PacifiCorp establish a decommissioning fund to be an environmental measure. Typically, the Commission would address the need for any such funding in its license order pertaining to this proceeding. Regarding the Hoopa Valley Tribe's recommendation that, in the event that PacifiCorp proposes to abandon any of the project facilities, PacifiCorp remove or modify project facilities and restore pre-project conditions to maintain fish and wildlife production, this issue, and others like it, would be addressed in a separate license amendment or

surrender proceeding, during which conditions for abandonment would be established after confirming that another party does not want the license.

Effects of Mainstem Dam Removal on Fish Disease

Removal of one or more of the mainstem dams could reduce the incidence of fish disease in the Klamath River downstream of Iron Gate dam through several potential mechanisms. As discussed in section 3.3.2.2.2, *Water Quality*, removal of Iron Gate and Copco No. 1 dams would have a much greater effect on water quality below the current site of Iron Gate dam than removal of Copco No. 2 or J.C. Boyle dams, since these reservoirs have longer residence times and more prevalent blooms of nitrogen-fixing blue-green algae. Removal of Keno dam would have important effects on temperatures within the current Keno impoundment, which we discuss below. While the river would continue to receive high nutrient loads from Upper Klamath Lake and the Klamath Straits drain, the effects of these inputs on fluctuations in DO, pH, and ammonia would be moderated by natural aeration from turbulent passage of water in areas of higher gradient that are currently inundated by the reservoirs. Because this genus of algae is typically most prevalent in areas that are closest to a nutrient source, the section of river where *Cladophora spp.* dominates would likely move upstream from its current location between Iron Gate dam and the Shasta River to the areas that are currently inundated, and would become less prevalent downstream of the current site of Iron Gate dam. Restoring access to these reaches for anadromous fish would allow adult fall Chinook salmon to distribute over a greater length of the river, reducing crowding and the concentration of disease pathogens that currently occur in the reach between Iron Gate dam and the Shasta River.

Removal of one or more of the project dams would also reduce thermal warming and eliminate the thermal lag associated with impounded reaches; but diurnal variations in temperature would increase. PacifiCorp's modeling of water temperatures with and without the project dams in place is shown in figures 3-52 through 3-56.

As we discuss in section 3.3.2.2.2, *Water Quality*, removal of Keno dam would result in substantial changes to the thermal regime within and downstream of the formerly impounded area, as the surface area would be substantially reduced and the residence time of water passing through the formerly impounded area would be reduced. Figure 3-52 indicates that without the dam in place, daily mean temperatures would be reduced by as much as 2°C and daily minimum temperatures would be reduced by as much as 4°C from April through October. The lower water temperatures in this reach would be more suitable for supporting rearing and migrating salmonids. However, as we discuss in section 3.3.2.2.2 we expect that the continued loading of organic material from Upper Klamath Lake and the shallow nature of the relatively low gradient of the Klamath River currently submerged by Keno reservoir are conditions that would persist after dam removal, and may continue to exert an elevated biological oxygen demand throughout the water column. This may result in a continuation of DO conditions that are similar to current conditions, which are highly stressful for salmonids from mid-June through October. However, stressful DO conditions would not be likely to occur during the spring months when many smolts would migrate through this reach, so continuation of low DO conditions within this reach may not preclude the successful migration of salmon and steelhead smolts through this reach if anadromous fish are restored to areas upstream of the project.

Simulated water temperatures within the J.C. Boyle bypassed reach indicate that removal of the project dams would reduce daily minimum and mean water temperatures from April through October within the reach upstream of the spring inflows (figure 3-53), but would increase daily minimum, mean and maximum water temperatures downstream of the springs (figure 3-54). Lowered water temperatures upstream of the springs would improve conditions for rearing, migrating, and spawning salmonids in this relatively short (0.5 mile) section, but daily mean temperatures would still exceed 20°C during July and August, which may limit the value of this habitat for supporting rainbow trout and as holding habitat for spring Chinook salmon and summer steelhead. Increased water temperatures downstream of the springs

could adversely affect the suitability of habitat in this reach for salmonid rearing and as holding habitat for adult spring Chinook salmon and summer steelhead. Although salmonids in the Klamath River have greater tolerance to high water temperatures than salmonids in most other basins, we conclude that the higher water temperatures would increase disease susceptibility and cause a more rapid depletion of energy reserves due to increased metabolic rates under higher water temperatures. We conclude that these factors would reduce the value of this reach as holding habitat for spring Chinook salmon and summer steelhead.

Simulated water temperatures downstream of Copco No. 1 dam (figure 3-55) and Iron Gate dam (figure 3-56) indicate that removal of the project dams would have only minor effects on water temperatures from late April through June, but daily minimum temperatures would be reduced starting in July, and both minimum and average daily water temperatures would be reduced from August through October. Reduced water temperatures in July and August would improve conditions during the time period when most fall Chinook salmon smolts typically migrate through the lower Klamath River (figure 3-64). Lower temperatures from July through November would benefit migrating and spawning fall Chinook salmon. Lower water temperatures would reduce the potential for pre-spawning mortality and would likely result in improved gamete viability. Several studies conducted on Snake and Columbia river fall Chinook salmon have shown that survival-to-emergence is reduced when water temperatures are elevated during the spawning period. Geist et al. (2006) found that survival-to-emergence was reduced at water temperatures exceeding 16.5ºC, Olson and Foster (1955) reported that the highest egg survival for fall Chinook salmon occurred for the group that was spawned at 11.7°C, and Olson et al. (1970) demonstrated a significant increase in egg mortality at spawning temperatures higher than 13.7°C. However, because Klamath River salmonids are generally more tolerant of high water temperatures than salmonids from other basins, it is possible the temperature at which gamete viability of Klamath fall Chinook salmon is affected may be higher than those reported in the studies cited above.

More rapid cooling of river temperatures in the fall with the project dams removed may also allow for fall Chinook salmon spawning to occur earlier in the fall. This, in turn, would likely result in earlier emergence and growth, and encourage earlier emigration. In addition, a slight increase in the rate at which water temperatures increase in the spring would be likely to improve the growth rates of newly emerged fall Chinook salmon fry, but average and daily maximum water temperatures would also increase to stressful levels earlier in the summer than currently occurs (see figure 3-55). The increase in average and maximum daily temperatures, however, may be compensated for by lower temperatures at night, which NAS (2004) concludes may allow rearing fish to move out of temperature refugia to forage at night, allowing growth to occur even when ambient temperatures are above optimal. Restoring natural sediment transport processes would likely contribute to the scour of attached algae downstream of the current site of Iron Gate dam, and deposited gravel and sand would provide a less favorable substrate for attached algae because of its greater mobility during high flow events than the existing armored substrate. The reduction in attached algae would provide less habitat for the polychaete intermediate host of *C. shasta* and *P. minibicornis*, which should reduce the infection rate of juvenile salmonids downstream of Iron Gate dam. Because temperature is a primary influence in growth of attached algae, eliminating the thermal lag would also shift the growing season for attached algae, which would likely reduce diurnal swings in DO and pH related to algal respiration in the late summer and early fall, but could increase these effects in the early summer.

Removal of Copco No. 2 and J.C. Boyle dams would be expected to have much less of an effect on water quality conditions than the removal of Keno, Copco No. 1, and Iron Gate dams, due to their smaller reservoir volumes, shorter residence times, and lack of substantial algae blooms. However, removal of Copco No. 2 and J.C. Boyle dams also would be expected to increase nutrient uptake by attached algae due to increased flow volumes in the bypassed reaches and reduced flow fluctuations in the J.C. Boyle peaking reach. Removal of Keno dam would cause a more substantial reduction in water temperatures due to the larger surface area of the reservoir, which contributes to substantial warming

during the summer months. However, water passing from Keno dam equilibrates with ambient temperatures as it travels downstream, and any effect on downstream water temperatures from its removal is unlikely to persist downstream of the current site of Iron Gate dam. Keno dam removal would likely result in a minor reduction in some nutrients, especially nitrogenous forms, because conditions would be less favorable for blooms of *Aphanizomenon flos-aquae*. However, nutrient levels in the vicinity of Keno would remain high because of inputs from Upper Klamath Lake and the Klamath Irrigation Project.

Effects of Dam Removal on Anadromous Fish Restoration

Removal of one or more mainstem project dams would improve the prospects for restoring anadromous fish to areas upstream of the project in the following ways:

1. Based on our previous analysis, removal of one or more of the larger project reservoirs (particularly Iron Gate and Copco reservoirs) would likely reduce the incidence of disease in the lower Klamath River migratory corridor and would reduce the risk of further declines before habitat restoration efforts in the upper basin begin to take effect and strategies for restoring passage to instream habitat can to be developed, tested, and implemented. Huntington et al. (2006) suggest that hatchery supplementation may be required over multiple generations to develop stocks of spring and fall Chinook salmon that are capable of migrating through Upper Klamath Lake and Keno reservoir during time periods when water quality conditions are suitable.
2. Removal of Iron Gate and Copco dams would restore 12.7 miles of inundated mainstem habitat that would provide substantial spawning habitat for fall Chinook salmon. We base this conclusion on the similar gradient of the reach to the area between Iron Gate dam and the Shasta River that is currently heavily used by spawning fall Chinook salmon and by reports of substantial spawning activity in the Copco No. 2 bypassed reach (Coots and Wales, 1952). Under this scenario, we assume that upstream and downstream passage would be provided at Copco No. 2 dam and J.C. Boyle dams. We estimate that the habitat that would be made available by the removal of Iron Gate dam could support about 4,100 spawning fall Chinook salmon, and the additional habitat that would be made available by removing Copco No. 1 dam could support another 7,700 adult fall Chinook salmon.[85] We note, however, that many factors influence adult returns, and our estimates assume that water quality and disease-related losses in the lower Klamath River migratory corridor are reduced by dam removal or by actions (including actions taken by other parties) to reduce nutrient loading and water temperatures or to improve streamflows during the migration season. These reaches would also be likely to support smaller numbers of coho salmon and steelhead.
3. Removal of one or more dams would eliminate losses of anadromous fish associated with reservoir and dam passage at the dams that are removed. Removal of Iron Gate dam provides the greatest potential to expand the range of Pacific lamprey, a species of cultural importance to the

[85]We used a density of 284 spawners per mile for tributary habitat based on spawner densities reported in Jenny and Fall creeks in Coots and Wales (1952) and Coots (1957). We used a density of 428 spawners per mile for low gradient mainstem habitat (Copco No. 2 bypassed reach and reaches inundated by Iron Gate and Copco reservoirs) and 214 spawners per mile in high gradient habitat (J.C. Boyle bypassed and peaking reaches) based on spawner counts reported in Coots and Wales (1952) for the Copco No. 2 bypassed reach. For low gradient mainstem habitat, we used a density two times that reported by Coots and Wales (1952) for the Copco No. 2 bypassed reach, because they also reported that a large amount of available spawning habitat was not used at the time of their survey.

tribes, to potential habitat upstream of Iron Gate dam.[86] Because of poor swimming ability of the species and its tendency to become impinged on screens, effective downstream passage technology for this species has not been developed. It also appears likely that the existing hatchery fish ladders which PacifiCorp would use to collect adult fish for upstream transport under its alternative prescription would not be effective for collecting Pacific lamprey for upstream transport, as PacifiCorp reports that lamprey have never been observed in these ladders.

We do not concur with Oregon Fish & Wildlife's recommendation that a decommissioning plan should be prepared for any development where effective upstream or downstream passage cannot be provided. Due to the serious water quality problems that exist in Keno reservoir and, at times in other project reservoirs, we conclude that trapping and transporting fish around one or more of the project reservoirs is likely to be part of any near-term passage solution that is implemented. The fishway prescriptions incorporate a trapping and transporting strategy that recognizes that, at least during certain periods, volitional fish passage may not be desirable unless substantial enhancements of water quality in Keno reservoir occurs. Furthermore, we are convinced that providing volitional passage at all project dams would provide little or no benefit unless disease issues in the downstream migratory corridor are effectively addressed.

The Yurok Tribe recommendation that the Commission enlist the help of stakeholders, agencies, and outside experts to decide the future fate of Iron Gate Hatchery and other potential artificial propagation programs in the event of decommissioning would help guide the discussion of the role of the hatchery in restoration efforts in the Klamath Basin. If the dams were decommissioned, the original purpose of the hatchery, to compensate for lost production upstream due to blocked access created by Iron Gate dam, would no longer exist. However, the Commission has authority only over a licensee of a hydroelectric project, not stakeholders who may be interested in the role that Iron Gate Hatchery should play following any decommissioning action. We consider it most appropriate for state, federal, and tribal resource agencies to be responsible for determining the future role of the Iron Gate Hatchery. If Iron Gate development, or other project developments should be decommissioned at some time in the future, the Commission would address decommissioning in a surrender proceeding, not in this relicensing proceeding. The Commission could establish a forum for appropriate parties to discuss the disposition of Iron Gate Hatchery, as part of a decommissioning plan, but we consider it premature to anticipate what the Commission would include in any decommissioning order that may be issued.

Adverse Effects of Dam Removal on Aquatic Resources

As we discussed in section 3.3.2.2.2, *Water Quality*, there are potential adverse effects from the release of sediments that may be contaminated with pesticides from upstream agricultural sources. We note, however, that testing of 26 sediment samples collected from project reservoirs suggest that there may be little or no contamination risk if sediments are eroded downstream. With the exception of one location in Copco No. 1, GEC (2006) reported that none of the sediment tested exceeded Puget Sound Dredged Disposal Analysis screening level criteria. That location contained volatile hydrocarbons that easily evaporate when exposed to air. GEC (2006) also concluded that less than 4 million cubic yards of fine sediment would erode downstream to the marine environment in the event of decommissioning; the duration of sediment transport could be compressed to a period ranging from 1 to 4 months, thereby avoiding or diminishing adverse effects associated with substantial sediment transport; and sediment

[86]We are not aware of any conclusive evidence that Pacific lamprey historically occupied habitat upstream of Iron Gate dam. However, Hamilton et al. (2005) conclude that Pacific lamprey likely migrated as far upstream as Spencer Creek, based on the extent of Pacific lamprey migrations in other coastal rivers, their general congruence with anadromous salmonid distributions, the historical absence of lamprey passage barriers in the mainstem Klamath River, and the homogeneity of the lower Klamath River fish fauna throughout the mainstem Klamath upstream to Spencer Creek.

transport below Iron Gate, even under the most conservative estimates, would not result in any downstream flooding.

In the near term, an increase in fine sediments can be expected to reduce the quality of fall Chinook salmon spawning habitat downstream of Iron Gate dam, and substantial increases in suspended sediment concentrations could adversely affect the health of and the food supply available to rearing salmonids and the health of salmon and steelhead that migrate through the lower Klamath River during periods of high turbidity. Adverse effects from high silt loads in mainstem spawning habitat would persist for a longer time period, perhaps for several years. We note, however, that the quantity and quality of available spawning habitat would likely increase in the long term by restoring the transport of spawning gravels from areas upstream of Iron Gate dam. Any adverse effects that occur to spawning fall Chinook salmon would be limited to fish that spawn in the mainstem Klamath, and not the majority of fall Chinook salmon that spawn in its tributaries, although depending on the timing of any dam removals, adult upstream migration to those tributaries could be slowed by increased turbidity and suspended solids. Removal of the mainstem dams would also eliminate existing warmwater fisheries and habitat for adult shortnose and Lost River suckers in the project reservoirs. It would, however, increase the abundance and distribution of most native species of resident and anadromous fish.

East Side and West Side Decommissioning

Decommissioning of East Side and West Side developments would prevent suckers from being entrained through turbines at these developments where they may suffer mortality during passage. However, if the NMFS/Interior fishway prescription is implemented, this would include the installation of fish screens and smolt collection facilities at East Side and West Side developments, which would reduce or eliminate the entrainment of juvenile and adult suckers through project turbines, assuming generation is occurring.

Implementing PacifiCorp's alternative prescription could also result in fish screens being installed at East Side and West Side developments, since its alternative includes the construction of a smolt collection facility at a site to be selected upstream of J.C. Boyle dam. If juvenile migration studies conducted under the adaptive management plan (included in its alternative prescription) determine that water quality conditions in Keno reservoir are not sufficient to allow for successful migration, location of the smolt collection facility at Link River dam may be the only option that would provide effective downstream passage past Keno reservoir.

Because of the possibility that fish screening facilities would be installed at East Side and West Side developments, we conclude that it could be appropriate for PacifiCorp, in the process of preparing a decommissioning plan, to consult with NMFS, FWS, and Reclamation to determine whether it would be beneficial to include any accommodations that would facilitate the potential future construction of a smolt collection facility at Link River dam.

3.3.3.2.5 Anadromous Fish Restoration

Numerous stakeholders have expressed strong interest in restoring anadromous fish to habitat within and upstream of the project area, either through implementing fish passage measures at project facilities or through dam removal. A framework for restoration of anadromous fish in the Klamath River Basin is established in "Long range plan for the Klamath River Basin conservation area fishery restoration program" (Task Force, 1991). This plan notes that although previous analyses, including Fortune et al. (1966) recommended against providing fish access over Copco dam, providing access to return anadromous fish to historic habitat needs to be re-evaluated considering current knowledge and conditions. The 1992 amendment to this plan (Task Force, 1992) points out that: "Disease introduction related to reintroducing anadromous fish to the Upper Klamath River is a major concern and potential problems must be resolved before any action is taken." The amendment also states: "Restoring runs of

Chinook salmon would not be wise to attempt at present because of degraded water quality and habitat programs in the Upper Klamath Basin."

A successful anadromous fish restoration program has the potential to increase fish production by allowing anadromous fish to use historical production areas within and upstream of the project and would provide access to important thermal refugia, most notably in the J.C. Boyle bypassed reach and in tributaries upstream of Upper Klamath Lake. Restoration of anadromous fish upstream of Iron Gate dam could restore Tribal and recreational fisheries over a very large geographical area (extending over more than 350 miles of riverine habitat), and could contribute to recovery of the SONCC coho salmon ESU. Increasing the abundance and geographic distribution of anadromous fish would increase the genetic diversity and resiliency of populations, and would help to restore and protect Tribal, commercial, and recreational fisheries both upstream and downstream of Iron Gate dam. Anadromous fisheries were recognized as an outstandingly remarkable value when the 189-mile-long lower Klamath River (extending from 3,600 feet downstream of Iron Gate dam to the Pacific Ocean) was designated by Congress in 1981 as a Wild and Scenic River.

Proposals to restore anadromous fish to areas upstream of Iron Gate dam that we evaluated in the draft EIS, included three distinct approaches. NMFS/Interior's modified fishway prescription, filed on January, 29, 2007, involves the installation of volitional passage facilities at all project dams but includes a trap and haul option for transporting juvenile and adult fish past Keno reservoir when water quality conditions are adverse. PacifiCorp filed an alternative to NMFS/Interior's preliminary prescription on April 25, 2006, which involves initiating feasibility studies to be followed by a trap and haul approach to provide passage between Iron Gate dam and J.C. Boyle reservoir, if studies indicate that establishing self-sustaining runs of anadromous fish is possible. The third approach involves the removal of some or all of the mainstem dams, and our analysis focuses on removing Copco No. 1 and Iron Gate dams which present the greatest challenges to fish passage needs and addressing water quality concerns.

PacifiCorp filed another alternative fishway prescription on December 1, 2006, which includes construction of volitional downstream fishways at each dam consistent with NMFS/Interior's prescription, implementing an adult trap and haul program, initially using the existing collection facilities at Iron Gate dam, and constructing a second adult trap below Copco No. 2 dam in year 4. Construction of downstream passage facilities would be deferred for 4 years in which PacifiCorp would conduct juvenile and spill survival studies, and may recommend modifications to the downstream fishway prescriptions based on study results. This alternative also commits PacifiCorp to fund, sponsor and participate in a technical committee to provide input to project-related fish passage, hatchery, anadromous fish restoration, and enhancement measures consistent with articles included in the new license. PacifiCorp also commits to the construction of tailrace barriers and spillway modifications and a new upstream fishway at J.C. Boyle if these facilities are determined to be needed based on the results of monitoring studies, and to provide additional hatchery compensation if an upstream passage survival rates of less than 95 percent is observed. The alternative also includes a commitment to fund 100 percent of the marking of fish produced at Iron Gate Hatchery, and a mechanism for reducing hatchery production over time according to the number of juvenile fish produced upstream of Iron Gate dam.

In response to numerous comments from stakeholders, we expanded our analysis in this EIS to include two specific dam removal alternatives: (1) removal of two mainstem dams (Copco No. 1 and Iron Gate) and (2) removal of four mainstem dams (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate). We also received many comments on the draft EIS that indicated concern that the measures included in the Staff Alternative would delay the reintroduction of anadromous fish while studies are conducted, and that the plans to address issues related to anadromous fish restoration, water quality, and fish disease contained an insufficient level of detail about what specific measures would be implemented and did not provide a firm timeline for their implementation. In response to these comments we developed a new approach that would proceed immediately with reintroduction of anadromous fish species upstream of Iron Gate dam, at the same time implementing an integrated study program to identify and implement the

most effective methods for addressing project effects on anadromous fish passage, water quality, and fish disease. We include a detailed description of this integrated approach at the end of this section.

As part of its December 1, 2006, alternative, PacifiCorp would organize, fund, and utilize a fisheries technical committee (FTC), consisting of NMFS, FWS, Bureau of Land Management, Reclamation, Oregon Fish & Wildlife, Cal Fish & Game, the Klamath Tribes, the Yurok Tribe, the Karuk Tribe, the Hoopa Valley Tribe, Siskiyou County, and an NGO representative that would be responsible for developing and making recommendations on reintroduction plans and actions to maximize the effectiveness of anadromous fish reintroduction and fisheries mitigation, protection and enhancement consistent with Commission license articles.

Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that PacifiCorp establish a fish passage implementation committee. The committee would consist of PacifiCorp, and, to the extent of their interest in participating, NMFS, FWS, Forest Service, the Bureau of Indian Affairs, Bureau of Land Management, Oregon Fish & Wildlife, Cal Fish & Game, Water Board, Oregon Environmental Quality, the Klamath, Karuk, Hoopa Valley, and Yurok tribes, and two representatives of non-governmental organizations. Unless specified otherwise, PacifiCorp would allow a minimum of 60 days for the committee members to comment, work to achieve consensus, and make recommendations before filing any study, operating, or implementation plan, report, or facility design with the Commission. If any of the fisheries management agencies (NMFS, FWS, Oregon Fish & Wildlife, or Cal Fish & Game) disapprove of a study, operating or implementation plan, report, or facility design, PacifiCorp would not submit the document to the Commission until a dispute resolution process has been completed. In their recommendation, the Hoopa Valley Tribe includes their fisheries department, Hoopa Fisheries, among the fisheries management agencies.

Interior recommends that PacifiCorp establish and fund the administrative costs for a fisheries technical committee to advise the licensee on the development of plans and environmental measures related to implementation of the new license. FWS also recommends that within 2 years, PacifiCorp prepare a Pacific lamprey management plan. The plan would include provisions for telemetry studies to evaluate upstream and downstream passage of Pacific lamprey through project fishways and reservoirs. It would also include measures to monitor and evaluate the timing of juvenile lamprey outmigration through the project, downstream passage routes and proportion of juvenile lamprey using each route, juvenile lamprey survival through the project, and the effects of reservoir fluctuations on juvenile lamprey rearing. The results of these studies and information from other Klamath Basin facilities would be used to direct operational and structural improvements to project fishways and to develop and implement plans to modify or replace existing project structures and operations to achieve upstream and downstream survival and passage levels that are commensurate with the best levels achieved elsewhere in the Klamath Basin. Any actions taken under this plan would be monitored to assess success of the measures.

The Klamath Tribes filed a reintroduction plan (Huntington et al., 2006), which lays out a conceptual framework for reintroducing and restoring self-sustaining populations of anadromous fish to the Upper Klamath Basin. The plan includes an initial phase of experimentation to confirm or refine hypotheses about how juvenile anadromous fish perform in different areas, and to assess suitable stocks for reintroduction. After passage is provided (by dam removal or through construction of fish passage facilities), the reintroduction effort would shift to systematically developing locally adapted populations above the current site of Iron Gate dam. The tribe's section 10(a) recommendations filed with the reintroduction plan include denial of a new license and ordering the removal of the lower four dams within 5 years of license denial, funding efforts to reintroduce and restore Chinook salmon and steelhead and their habitats in all areas downstream of, within, and upstream of the project where the project has prevented access or substantially contributed to their decline, and funding a group of state, federal, and tribal technical experts to provide recommendations and guidance to fisheries managers on maximizing the utility of Iron Gate Hatchery for anadromous salmonid restoration and management efforts.

Siskiyou County recommends that PacifiCorp develop a fish passage plan that recognizes that fish re-introduction would most likely need to take place over the long-term to be effective, cost efficient, and result in minimal risk to current fish stocks. Studies and modeling would be used to evaluate what fish passage scenarios provide the most benefit for the least cost.

As part of the adaptive management plan that it includes in its April 25, 2006, alternative fishway prescription, PacifiCorp would evaluate juvenile salmonid survival through lakes and reservoirs from March through June 15 and from September through October, including the provision of up to 250 radio tags each year. Any juvenile fish collected during the juvenile downstream passage study would be transported to holding facilities at the Iron Gate Hatchery to assess their survival during transport by truck. PacifiCorp would collect adult salmonids at Iron Gate dam, tag them, transport them to various release sites upstream of J.C. Boyle dam, including the Williamson and Wood rivers, and conduct spawning surveys to determine if released fish successfully spawn. Radio tags would be used for tracking purposes, and survival during transport would be evaluated. PacifiCorp would uniquely mark all juvenile fish transported and released in the lower Klamath River, and would enumerate tagged fish upon their return to Iron Gate dam, possibly including a search of spawning areas to retrieve tags. The results would provide a basis for estimating smolt to adult survival for a minimum of 5 brood years. PacifiCorp would also monitor early life history and migration in upper Klamath basin tributaries (e.g., Wood and Williamson rivers) using screw traps to determine survival rate, whether the dominant life-history expressed by reintroduced fish is an ocean-type (migrating to the ocean as subyearlings) pattern or spring-type (migrating to the ocean as yearling) pattern, and when juvenile migration begins and ends. Based on the results and analysis of these Phase 1 studies, fisheries managers would decide if self-sustaining runs of anadromous fish can be established. If the fisheries managers conclude that self-sustaining runs can be established, PacifiCorp would design permanent juvenile collection facilities at or above Boyle dam, modify the adult collection facility at Iron Gate dam, and implement a reintroduction program using a trap and haul approach. If fisheries managers decide self-sustaining runs of anadromous fish cannot be established, PacifiCorp would conduct a limiting factors analysis to identify obstacles for establishing such runs. PacifiCorp would not have any responsibility for addressing an identified limiting factor, but if others are successful in removing the obstacle, PacifiCorp would conduct studies to confirm that the factor is no longer limiting, and if not, implement reintroduction efforts. PacifiCorp's December 1, 2006, alternative fishway prescription includes a commitment to specific and vigorous research, monitoring, and evaluation pertaining to anadromous fish reintroduction efforts.

NMFS/Interior filed a modified joint fishway prescription on January 29, 2007. The modified prescription retains the same overall approach as the preliminary prescription, with several modifications: (1) the modified prescription included provisions that would allow the need for and design of spillway modifications and tailrace barriers to be determined based on site-specific studies; (2) the modified prescription would allow the need for measures to improve passage in the Copco No. 2 bypassed reach (by modifying the rock ledge or bypassed flows) to be determined based on an evaluation of fish passage under normal operating flows in the new license; and (3) the existing ladder and holding tanks at Iron Gate dam would be modified to allow the collection and handling of resident trout and lamprey.[87]

[87]Section 2 of the modified prescription stated that the modified fishway prescription has been revised to accommodate upstream passage of lamprey and resident trout. However, the nature of this modification is not described, so we cannot evaluate its potential benefits.

Our Analysis

Our general assessment of the potential risks and benefits of the three alternative approaches for restoring anadromous fish is summarized in table 3-73. We include both a two and a four mainstem dam removal alternative in our assessment of dam removal approaches; we did not include the latter in our draft EIS. The NMFS/Interior prescription takes the approach of requiring volitional upstream and downstream passage facilities at each development and tailrace barriers at each of the project powerhouses with the exception of Iron Gate dam, but also includes provisions for collecting smolts at Link River dam and adult fish at Keno dam to transport past Keno reservoir when water quality conditions are adverse. Although provision of facilities that would allow fish to be trapped and trucked around Keno reservoir adds flexibility to the passage approach that can be taken, the prescription does not appear to take into account the cumulative stress and mortality that may result from passage through the five project reservoirs and four screening facilities that would be constructed as the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams. Given the potential for predation and exposure to adverse water quality conditions during passage through project reservoirs and screening facilities, we conclude there is a strong basis for questioning whether the provision of volitional passage at each project development would provide any advantage or benefit over the trap and haul approach described in PacifiCorp's April 25, 2006, alternative prescription. This concern is consistent with the results of PacifiCorp's fish passage modeling studies,[88] which indicate that cumulative losses of juvenile and adult salmon under volitional passage could exceed those that would occur under a trap and haul approach (table 3-74), resulting in similar predicted run sizes despite the greater amount of habitat that would be made accessible within the project area through volitional passage (table 3-75). Regarding the potential need for tailrace barriers and spillway improvements at the J.C. Boyle, Copco No. 1 and Copco No. 2 developments, NMFS/Interior provide no site-specific evidence to suggest that injuries or migration delay is more likely to occur at the project spillways and powerhouses. We conclude that the provision to determine the need for spillway modifications and tailrace barriers based on site-specific studies, included in the NMFS/Interior modified prescription and PacifiCorp's December 1, 2006 alternative, is a prudent approach for addressing these issues. For the same reasons, we also conclude that determining the need for replacing the J.C. Boyle ladder based on site-specifically, as proposed by PacifiCorp in its December 1, 2006, alternative, is a prudent approach for ensuring effective upstream passage at the J.C. Boyle dam.

PacifiCorp's April 25, 2006, alternative prescription takes a more precautionary approach to addressing critical uncertainties that may affect the feasibility of restoration before making a substantial investment in a smolt collection facility upstream of J.C. Boyle dam. Although this is a slower-paced approach towards achieving anadromous fish restoration, the more deliberate and thorough examination of the constraints that affect passage through Upper Klamath Lake and Keno reservoir may contribute to a better understanding of migration timing requirements and assist with the selection of appropriate stocks for reintroduction. This alternative prescription includes a suite of studies that would be conducted during Phase 1 of the adaptive reintroduction plan, which are listed in table 3-76. Many of the key uncertainties would be addressed in the first 5 years of study. Although PacifiCorp indicates that some aspects of the Phase 1 studies may require 9-10 years to complete, we conclude that 5 years is probably sufficient time to address the key critical uncertainties, and to identify the most promising site for constructing a smolt collection facility, if warranted. We note, however, that many of the critical uncertainties regarding passage through Upper Klamath Lake have little or no direct relation to the effects of the Klamath Hydroelectric Project.

[88]These model runs were based on reservoir and passage survival rates observed in studies conducted in other river systems, and we acknowledge that their applicability to the Klamath needs to be verified through site-specific evaluations.

Table 3-73. Comparison of the benefits of four alternative approaches to anadromous fish restoration.[a] (Source: Staff)

	NMFS/Interior preliminary fishway prescription, NMFS/Interior modified fishway prescription (volitional and/or trap and haul passage at all project dams)	PacifiCorp's April 25, 2006, alternative prescription (trap and haul from below Iron Gate to above J.C. Boyle)	Remove Copco No. 1 and Iron Gate dams, fish passage at Copco No. 2, J.C. Boyle, and Keno dams	Remove Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle dams
Benefits	Provides access to 355 miles of habitat upstream of Upper Klamath Lake if migration through Upper Klamath lake is feasible. Provides access to 27.7 miles of mainstem habitat and 20.2 miles of tributary habitat within the project.	Provides access to 355 miles of habitat upstream of Upper Klamath Lake if restoration is determined to be feasible. Provides access to 14.7 miles of tributary habitat if passage to/from Spencer Creek is provided for coho salmon. All smolts could be trucked to a release point in the lower river, bypassing most passage risks including the disease "hot spot" upstream of the Shasta River confluence. Addresses critical uncertainties related to the ability of anadromous fish to migrate through Upper Klamath Lake and Keno reservoir.	Provides access to 355 miles of habitat upstream of Upper Klamath Lake if migration through Upper Klamath lake and Keno reservoir is feasible. Provides access to 40.4 miles of mainstem habitat (including habitat now inundated by Iron Gate and Copco reservoirs) and more than 20.2 miles of tributary habitat within the project. Risks during downstream passage through the project reach and the lower Klamath River would be substantially reduced through less predation and improved water quality. Disease risk to salmon downstream of Iron Gate dam and in lower river tributaries are likely to be reduced due to reduced crowding, increased scour of algae and pathogens, reduced nutrients and improved water quality. Spawning and rearing habitat downstream of Iron Gate dam would be substantially improved due to restoration of sediment transport increasing spawning gravel and channel complexity.	Same as two-dam removal, but would restore an additional 3.9 miles of inundated mainstem habitat and a short section of Spencer Creek (less than 0.25 mile), provide some additional reduction in predation and water quality improvement, restore gravel transport and improve spawning and rearing habitat in the J.C. Boyle bypassed and peaking reaches and in the Copco No. 2 bypassed reach, improve water quality and fish production by restoring higher flows to project bypassed reaches and eliminate adverse effects from flow fluctuation in the J.C. Boyle peaking reach.

	NMFS/Interior preliminary fishway prescription, NMFS/Interior modified fishway prescription (volitional and/or trap and haul passage at all project dams)	PacifiCorp's April 25, 2006, alternative prescription (trap and haul from below Iron Gate to above J.C. Boyle)	Remove Copco No. 1 and Iron Gate dams, fish passage at Copco No. 2, J.C. Boyle, and Keno dams	Remove Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle dams
Risks	Slight risk of transmission of disease (especially Infectious Hematopoietic Necrosis [IHN]) to upper watershed. Moderate to high risk that benefits could be reduced by disease losses in the lower Klamath River unless disease management efforts in the lower river are successful.	Slight risk of disease (especially IHN) to upper watershed. Moderate to high risk that benefits could be reduced by disease losses in the lower Klamath River unless disease management efforts in the lower river are successful.	Slight risk of transmission of disease (especially IHN) to upper watershed. Slight risk that increased water temperatures in the spring could increase disease losses in the lower Klamath River. Silt deposition downstream of Iron Gate dam may reduce mainstem spawning success for several years. Effects of dam removal on water quality parameters are difficult to predict, but some adverse effects may occur. Fisheries for fall Chinook salmon may need to be curtailed due to loss of hatchery water supply to Iron Gate Hatchery when Iron Gate dam is removed.	Same as two-dam, except that water temperatures in the J.C. Boyle bypassed reach would increase; likely reducing its value as a temperature refugia for adult summer steelhead and spring Chinook salmon. Slight increase over the two-dam removal alternative in the amount of silt deposition that would occur downstream of Iron Gate dam.

[a] All estimates of the miles of anadromous fish habitat that would be made accessible under each alternative are approximate, given limited and conflicting information on the condition and suitability of habitats that would be made accessible to anadromous fish species.

Table 3-74. Cumulative average survival estimates for all-volitional and collection and transport alternatives used in the KlamRAS fish passage model for fall Chinook salmon originating above Upper Klamath Lake. (Source: Oosterhout, 2005a, cited from PacifiCorp, 2006b)

Life Stage	Destination Node	Average Cumulative Survival All-Volitional	Average Cumulative Survival Collection and Transport
Juveniles	Above Upper Klamath Lake to below Link dam	0.78	0.78
	Below Link dam to below Keno dam	0.63	0.63
	Above J.C. Boyle to below J.C. Boyle	0.54	0.54
	Above Copco to below Copco	0.46	Transport
	Above Iron Gate Dam to below Iron Gate Dam	0.42	Transport
	Below Iron Gate Dam to ocean	0.34	0.42
Adults	Ocean to Iron Gate Dam	0.98	0.98
	Below Iron Gate Dam to above Iron Gate Dam	0.90	Transport
	Below Copco to above Copco	0.77	Transport
	Below J.C. Boyle to above J.C. Boyle	0.70	Transport
	Below Keno to below Link	0.65	Transport
	Below Link to above Upper Klamath Lake	0.60	0.68 (0.79)[a]

[a] For adults transported from Iron Gate dam to above Upper Klamath Lake.

Table 3-75. Estimated adult anadromous fish abundance under volitional passage and trap and haul alternatives. (Source: Oosterhout, 2005b; PacifiCorp, 2005e)

	All-Volitional Passage		Trap and Haul	
Species	EDT	KlamRAS	EDT	KlamRAS
Fall Chinook	3,169	29,754	3,619	28,539
Spring Chinook	1,354	--	2,674	--
Steelhead	358	--	363	--

Notes: EDT -- Ecosystem diagnosis and treatment model
KlamRAS -- This model incorporates both habitat data (from EDT) and fish passage survival through project structures to estimate fish production in specific reaches or areas of the basin.

Table 3-76. Phase 1 studies under PacifiCorp's April 25, 2006, alternative prescription. (Source: PacifiCorp, 2006b)

Critical Uncertainty	Study Name	Time Frame	Facilities
Can juveniles migrate successfully through Upper Klamath Lake, Lake Ewauna, and J.C. Boyle reservoir?	Juvenile survival through Upper Klamath Lake, Lake Ewauna, and J.C. Boyle reservoir	5 years	Monitoring facilities at A-canal and J.C. Boyle, additional juvenile collectors as needed
What is the survival rate for transported juveniles?	Juvenile Transport Survival	5 years	Transport system at A-canal, J.C. Boyle, and any temporary facilities.
What is the overall survival rate of transported adults?	Adult Survival and Behavior During Transport and Migration	5 years	Upper Klamath release sites.
Can adults migrate successfully through lakes and reservoirs?			

Critical Uncertainty	Study Name	Time Frame	Facilities
What is the representative range of SAR for Upper Klamath River Origin anadromous fish?	Smolt-to-Adult Survival Rate	5 brood years 9 years	No new facilities expected; dependent on mark type.
Does the release of anadromous fish to the upper basin result in increased disease related mortality on local rainbow and other resident fish species?	Disease (Juvenile and Adult)	10 years	None.
What is the behavior and early life-stage survival of juvenile fish produced from the upper basin?	Early Life Stage Survival and Juvenile Production	10 years	Screw-traps at mouth of key tributaries.

One limitation of using a single smolt collection facility to transport smolts past the other project dams is that some outmigrating smolts would avoid collection by passing over the spillway when flows exceed the capacity of the screening facility. These fish would then be subject to entrainment and potential turbine mortality at downstream developments. This risk, however, could be assessed via radio telemetry studies conducted during spill events, which would allow the potential benefits of shutting down or reducing generation at specific developments during peak migration periods to be evaluated. A second limitation is that a single screening facility would not help to restore anadromous fish to habitat downstream of the screening facility. However, as reflected in table 3-74, a reduction in mortality associated with reservoir passage may more than compensate for the lost production potential from bypassed habitat, if the level of mortality caused by transport is lower than the mortality experienced by in-river migrants. A third risk is that a trap and haul approach requires an active and consistent effort for it to be implemented effectively, while a volitional fish passage approach requires a more limited effort to verify and ensure that they are operating effectively.

As we discuss in section 3.3.3.2.3, *Disease Management*, neither the NMFS/Interior preliminary or modified prescription nor PacifiCorp's alternative prescription address disease issues in the lower river migratory corridor. We reiterate our concern that, unless this issue can be addressed both promptly and effectively, implementing fish passage through the project may yield little or no benefit, especially for the fall Chinook salmon stock, which is of great value to tribal, commercial, and recreational fisheries.

The third approach to anadromous fish restoration, removing one or more of the project dams in conjunction with provision of fish passage at the remaining dams, probably holds the greatest promise for restoring anadromous fish species, especially if Iron Gate and Copco No.1 dams are removed. As we discuss in section 3.3.3.2.4, *Dam Removal or Decommissioning*, this approach would be likely to reduce fish stress and disease losses in the lower Klamath River by improving water quality, and would provide access to additional spawning habitat that is currently inundated by Iron Gate and Copco reservoirs.

We also consider removal of Iron Gate dam and additional upstream dams to be the only feasible step that could be expected to expand the current range of Pacific lamprey to areas upstream of Iron Gate dam. We consider it highly unlikely that the telemetry studies recommended by FWS, as part of its recommended Pacific lamprey management plan, would lead to the identification of structural or operational changes that would allow juvenile lamprey to migrate successfully through the project. Pacific lamprey are a weak-swimming species that are very vulnerable to predation, and there is no

information in the record to indicate that juvenile lamprey could migrate successfully through large reservoirs such as Copco and Iron Gate. Furthermore, the species is vulnerable to impingement on fish screens, and screening technology for this species is in its early stages of development. Finally, however, we note that, as the ALJ concluded, there is no conclusive evidence that the species occurred historically upstream of Iron Gate dam, and no Pacific lamprey have been observed entering the fish ladders at Iron Gate Hatchery.

Because any new license is likely to include a number of environmental measures that would have an adaptive management component, we conclude that it would be beneficial for PacifiCorp to establish and fund the administrative costs for a fisheries technical committee to advise PacifiCorp on the development of plans and environmental measures, as recommended by Interior and by PacifiCorp in its December 1 alternate prescription. The committee could provide an oversight role for all fisheries measures including those related to spawning gravel augmentation, disease management, and anadromous fish reintroduction. Because these measures are interrelated and involve many of the same areas of expertise, we do not see the need for or benefit of establishing a specific committee that would be charged with the oversight of anadromous fish restoration. Inclusion of all interested fisheries management agencies, affected tribes, and NGOs would be appropriate, given their shared interest in anadromous fish conservation and restoration.

In response to numerous comments from stakeholders, we developed a new approach which would proceed with the immediate reintroduction of anadromous fish species upstream of Iron Gate dam, while implementing an integrated program to identify the most effective methods for addressing important project effects on fish passage, water quality, and fish disease. This approach would address two critical uncertainties, discussed below, that could influence the success of reintroduction efforts. Without addressing these uncertainties, we conclude that the assumed benefits of implementing the NMFS/Interior prescriptions or PacifiCorp's alternative prescriptions are highly speculative. In the following section, we summarize the basis for our concerns related to these uncertainties, including references to and evaluation of findings from the September 27, 2006, ALJ decision that relate to these concerns. Finally, we lay out the components of an integrated approach and a detailed schedule for implementation of that approach.

The first critical uncertainty is whether substantial losses of outmigrating salmon smolts would occur during passage through project reservoirs under the NMFS/Interior prescriptions and under PacifiCorp's December 1, 2006, alternative, and whether these losses can be reduced using a trap and haul approach for downstream passage. In our review of the September 27, 2006, ALJ decision and its supporting record, our conclusions relating to reservoir passage differ from the ALJ's in three important aspects, which we summarize below.

1. The ALJ concludes that all anadromous species would outmigrate before the onset of high water temperatures, based in part on the assumption the migration of fall Chinook salmon smolts would be complete by the beginning of April. Our analysis, based on data from screw-trap sampling conducted by FWS at Big Bar (RM 49.7) in 1997, 1998, 1999 and 2000, shown in draft EIS figure 3-64, indicates that most hatchery and natural fall Chinook salmon outmigrate past Big Bar during July and August, and draft EIS figure 3-66 shows that most hatchery and wild coho salmon smolts outmigrated past Big Bar in May and June. Tables 3-68 through 3-70 show that water temperatures throughout the project reaches and in the Klamath River below Iron Gate dam typically become stressful for juvenile salmonids in early to mid-June and are typically highly stressful throughout the months of July and August. In addition, migration patterns observed in the Snake River Basin indicate that outmigrating juvenile fall Chinook salmon tend to delay their

migration and rear for up to a month in the first reservoir that they encounter.[89] If this behavior occurs in the Klamath River, it could cause any fall Chinook salmon smolts produced upstream of Iron Gate dam to outmigrate even later than the fall Chinook salmon that are currently produced downstream of Iron Gate dam.

2. The ALJ concludes that predation on outmigrating juvenile anadromous salmonids is a slight problem that could be minimized through use of remedial measures, and that few (yellow perch) exist in the project reservoirs." Our analysis includes the abundance data presented in tables 3-45 and 3-47, which shows that yellow perch was the most abundant fish species collected in Copco reservoir, and they were also the most abundant predacious fish species collected in Iron Gate reservoir.[90] Although FWS presented evidence in the EPAct proceedings that yellow perch sampled in the Klamath River downstream of the Copco dams in 1952 did not feed on Chinook salmon smolts (Coots, 1955), our analysis indicates that these results may have little bearing on predation rates that would occur in project reservoirs. Smolts migrating through the riverine environment that existed below the Copco developments in 1952 would have likely migrated in high velocity areas in the main channel of the river, where they would be unlikely to encounter yellow perch. Yellow perch are not a riverine species, and it is likely that the yellow perch sampled by Coots (1955) were residing in low velocity, backwater areas that would not used by outmigrating smolts. The tendency of fall Chinook salmon to rear for a period in the first reservoir that they encounter, as noted above, would further increase predation potential during passage through project reservoirs. Another study conducted in a more similar, non-riverine (lake) environment, reported that up to 40 percent of yellow perch sampled during a spring sampling period contained Chinook salmon smolts (Footen, 2003).

3. The ALJ concludes that because anadromous salmonids currently complete their life cycles through eight dams and reservoirs on the Columbia and Snake rivers, they should be able to migrate through the five project reservoirs on the Klamath. Our analysis reveals four additional factors that should be considered. First, all of the listed salmon and steelhead ESUs in the Snake River are subject to heavy rates of hatchery supplementation. Second, adult return rates to the Snake River are very low despite extensive measures that are undertaken each year to improve migration survival including extensive spill, smolt transportation and predator control programs. Third, critical water quality parameters are considerably more adverse in the Klamath River. Water temperatures in the Klamath River increase more rapidly in the spring and reach higher summer maxima in most years than they do in the Columbia River, and variations and extremes in DO, pH, ionized ammonia, and toxins associated with algae blooms are more severe in the Klamath River. Fourth, although anadromous fish in the Snake River must travel through more reservoirs on their route through the lower Snake and Columbia

[89] In a letter commenting on fish passage modeling assumptions associated with passage through the Hells Canyon project, NMFS states that "because fall Chinook salmon currently utilize Lower Granite Reservoir (the first reservoir encountered) as a rearing area for extended periods of time, survival in this reservoir is the lowest per km of any reservoir in the Snake River." They also suggest that fall Chinook salmon restored to areas upstream of the Hells Canyon Project would likely exhibit this tendency to rear for an extended period in the first reservoir that they encounter in their downstream migration (letter from K. Kirkendall, Chief of FERC and Water Diversions Branch, Hydropower Division, NMFS, to C. Jones, Hells Canyon project manager, Idaho Power, dated January 20, 2005).

[90] Although pumpkinseed sunfish were more abundant than yellow perch, this species is likely too small to feed on most juvenile salmon.

rivers, the reservoirs that these fish must negotiate are more riverine in nature. Lower average water velocities in the Klamath reservoirs are likely to result in slower rates of migration and increased exposure to predation. Considering the four factors described above, we are not convinced that observed successes with volitional fish passage on the Snake River would be necessarily transferable to the Klamath River.

The second critical uncertainty is whether substantial losses of outmigrating salmon smolts from infection with *C. shasta* and *P. minibicornis* would continue and perhaps escalate in the future, and whether measures can be implemented that would reduce these losses. We conclude that substantial disease losses are likely to continue and have the potential to become more severe given the current basin-wide trend of increasing water temperatures, unless substantial efforts are taken to reverse this trend. Even current rates of fall Chinook salmon disease losses may preclude the development of self-sustaining runs of anadromous fish upstream of Iron Gate dam, which would greatly reduce the potential benefit that would be derived from substantial investments in fish passage facilities. This risk is especially severe for fall Chinook salmon, but coho salmon are also at risk. Coho salmon are known to be susceptible to *C. shasta*, and their degree of exposure may increase if the disease becomes more prevalent in the population of adult fall Chinook salmon, whose carcasses are thought to seed the spawning grounds with disease spores. As discussed in section 3.3.3.1.4, *Diseases Affecting Salmon and Steelhead*, *C. shasta* infection rates among sampled fall Chinook salmon smolts averaged about 40, 19, 70 and 45 percent in 2001, 2002, 2004 and 2005, and Foott et al. (2004) concluded that most smolts with detectable levels of *C. shasta* infection were likely to die from the disease. Based on these data, we conclude that even a slight increase in average water temperatures or other factors that contribute to disease susceptibility could contribute to the continued decline of the fall Chinook salmon fishery. We also conclude that an increased prevalence of infection among fall Chinook salmon would increase the potential for losses of coho salmon due to infection with *C. shasta*.

The integrated approach to anadromous fish restoration that we present below proceeds immediately with the restoration of anadromous fish to areas upstream of Iron Gate dam, and with addressing the two critical uncertainties discussed above. Other factors that would be addressed include evaluation of the adequacy of proposed ramp rates in the J.C. Boyle peaking reach for minimizing fish stranding and reducing adverse effects on productivity of the rearing environment for resident and anadromous fish species. The specific schedule and components of this integrated approach are set out in detail below.

Year 1 – fish passage components

1. Consult with a stakeholder advisory committee to develop a Phase I implementation plan for Commission approval that describes the schedule and approach for implementing fish passage, disease management, monitoring, and study efforts to be implemented in the first 3 years of the program, with a focus on addressing critical uncertainties and determining optimal approaches for anadromous fish restoration and disease management. Include a provision for filing annual Phase I implementation reports including the results of monitoring to date, measures implemented in the past year, and measures proposed for implementation in the coming year. The stakeholder advisory committee should include NMFS, FWS, Cal Fish & Game, Oregon Fish & Wildlife, the Hoopa Valley, Karuk, Klamath, Quartz Valley, Resighini Rancheria, and Yurok tribes, and an NGO representative, to the extent they choose to participate.
2. Design a screening facility at J.C. Boyle that meets NMFS juvenile fish screening criteria, in accordance with the provisions specified in the NMFS and Interior fishway prescriptions.
3. Modify Iron Gate fish trap to facilitate the handling and loading of adult anadromous fish for trap and haul operations.

Year 1 – disease components

4. For pertinent water quality parameters that are amenable to continuous monitoring (temperature, DO, and pH), initiate continuous monitoring at a minimum of six locations in the Klamath River between Iron Gate dam and the mouth of the Klamath River, and in major tributaries near their confluence with the Klamath River. The monitoring effort at each location would continue for a minimum of 3 years, or longer if needed, to assess the contribution of the project to adverse water quality conditions downstream of the project.
5. At each location, conduct sampling and analysis every 2 weeks from March through November of: (1) un-ionized ammonia; (2) microcystin concentration; (3) attached algae species composition and biomass; (4) *M. speciosa* (*C. shasta's* polychaete alternate host) density; and (5) infection rate of *M. speciosa* with *C. Shasta* and/or measurement of pathogen spore density using quantitative polymerase chain reaction assays.

Year 2 – fish passage components

6. Initiate trap-and-truck of adult fall Chinook salmon, and other anadromous fish species to be determined by the stakeholder advisory committee, to be released upstream of the Copco No. 1 and J.C. Boyle dams.
7. Construct screening facility at J.C. Boyle and implement modifications of the J.C. Boyle fish ladder proposed by PacifiCorp.
8. Conduct radio-telemetry studies of released adult fall Chinook salmon to determine transport survival, ladder passage, spawning locations, usage of gravel added to the J.C. Boyle bypassed reach, and of temperature refugia in J.C. Boyle bypassed reach.
9. Initiate monitoring of fish stranding in the J.C. Boyle peaking reach.
10. Additional, feasible monitoring or fish passage-related studies identified by the stakeholder advisory committee and approved by the Commission.

Year 2 – disease components

11. Evaluate the relationship between smolt release location and *C. shasta* infection rates by releasing large groups of marked hatchery fall Chinook salmon smolts at different locations and determining infection rates of marked fish recovered at the FWS screw trap sampling site at Big Bar (RM 49.7). Initial releases would include one group released near Iron Gate dam and another group released downstream of the suspected high *C. shasta* infection zone near Beaver Creek (between Iron Gate dam and the Shasta River). Releases would be made on one or more dates during the middle and later portion of the migration season when *C. shasta* infection rates observed at Big Bar are typically high.
12. Initiate feasible laboratory or field evaluations of potentially viable pathogen control methods or additional disease-related monitoring identified by the stakeholder advisory committee and approved by the Commission.

Year 3 – fish passage components

13. Continue trap and haul of adult fall Chinook salmon, and other anadromous fish species to be determined by the stakeholder advisory committee.
14. Continue radio-telemetry studies of released adult fall Chinook salmon and possibly other anadromous fish species to determine transport survival, ladder passage (at J.C. Boyle), spawning locations, usage of gravel added to the J.C. Boyle bypassed reach, and of temperature refugia in J.C. Boyle bypassed reach.

15. Initiate the collection of outmigrating fall Chinook salmon smolts at the new J.C. Boyle fish screening facility and at the head of Copco reservoir using screw traps or other temporary collection devices.
16. Initiate radio telemetry studies to estimate the migration survival of wild fall Chinook salmon smolts passing through the Copco and Iron Gate reservoirs, entrainment survival through turbines, and the effects of different levels of controlled spill on spillway passage effectiveness and survival.
17. Conduct radio telemetry studies to determine the transport and migration survival of smolts transported to and released at one or more locations downstream of Iron Gate dam. Migration survival would be monitored using fixed antenna arrays installed at a minimum of two bridge crossing in the lower Klamath River. If a sufficient number of smolts are available, the study should include multiple release locations to compare survival rates associated with different transport distances and release locations. Monitoring of water quality parameters in each reach as specified below would allow relationships between short-term survival rates and water quality parameters to be evaluated, including diel variations in water temperature, DO and pH, and concentrations of unionized ammonia and microcystin.
18. Continue monitoring of fish stranding in the J.C. Boyle peaking reach, and modify operations if warranted.

Year 3 – disease components

19. Continue water quality, attached algae, pathogen, and microcystin monitoring, and any additional laboratory or field evaluations of potentially viable pathogen control methods.
20. Continue evaluation of the relationship between smolt release location downstream of Iron Gate dam and *C. shasta* infection rates.
21. Evaluate effects of spills at Iron Gate dam on water quality parameters including TDG, and effects of spill on *C. shasta* infection rates.

Year 4 – fish passage components

22. Continue trap and haul of adult fall Chinook salmon, and other anadromous fish species to be determined by the stakeholder advisory committee.
23. Continue radio-telemetry studies of released adult fall Chinook salmon and possibly other anadromous fish species to determine transport survival, ladder passage, spawning locations, usage of gravel added to the J.C. Boyle bypassed reach, and of temperature refugia in J.C. Boyle bypassed reach.
24. Continue collection of outmigrating fall Chinook salmon smolts and initiate collection of yearling coho salmon smolts at the new J.C. Boyle fish screening facility and at the head of Copco reservoir.
25. Draw Copco and Iron Gate reservoirs down to minimum operating pool in June (22.5 foot drawdown to 59 percent of full pool volume at Copco, 23-foot drawdown to 61 percent of full pool volume at Iron Gate) as rapidly as feasible. Hold reservoirs at this level until temperatures decline in the fall. Refill the reservoirs in the fall according to a schedule to be determined in consultation with the stakeholder advisory committee.
26. Conduct radio telemetry studies to assess the effect of reduced reservoir volume and increased water velocities on migration survival through Copco and Iron Gate reservoirs, and on turbine passage survival.

27. Conduct radio telemetry studies or releases of marked hatchery fish to evaluate the effect of the June pulse flow on the migration survival of fall Chinook salmon through the lower Klamath River.
28. Continue monitoring of fish stranding in the J.C. Boyle peaking reach, and evaluate the effect of modified operations, if warranted.

Year 4 – disease components

29. Continue water quality, attached algae, pathogen monitoring and any additional laboratory or field evaluations of potentially viable pathogen control methods.
30. Monitor the effects of the June pulse flow and of reduced reservoir volume on downstream water quality parameters, microcystin concentrations, pathogen density and disease incidence of smolts collected at the FWS screw trap sampling site at Big Bar.

Year 5+ – fish passage and disease components

31. Continue studies to address any remaining critical uncertainties related to project effects on water quality, microcystin concentrations, fish diseases, and fish passage survival.
32. Identify and implement the most beneficial and feasible methods for providing upstream passage at each project dam (continue trap and haul from Iron Gate until the most appropriate long-term approach is identified and implemented). Continue adult telemetry studies if warranted.
33. Identify and implement the most beneficial and feasible methods for providing downstream passage at each project dam.
34. Identify and implement the most beneficial and feasible methods to address adverse project effects on water quality and fish disease.
35. Consult with stakeholders to develop a Phase II implementation plan for Commission approval that describes the schedule and approach for implementing fish passage, disease management, monitoring, and study efforts to be continued into the future, and provisions for implementing adaptive management based on monitoring and study results. The plan would address the handling and disposition of any federally listed suckers collected that are collected in passage facilities, which could be returned to the waters upstream or downstream of the facility, in accordance with input from Interior and other parties consulted during plan development.

This alternative approach has the benefit of proceeding immediately with the reintroduction of anadromous fish species to habitat upstream of Iron Gate dam while addressing critical uncertainties. The integrated program would help to guide an efficient and effective anadromous fish reintroduction effort, and a process for developing solutions to water quality and fish disease issues downstream of Iron Gate dam. The alternative would also require PacifiCorp to fund and participate in an advisory committee formed of interested agencies, tribes, and NGOs to implement the integrated plan, and to fund the implementation of all studies, monitoring, and measures that are warranted and necessary to address project effects on anadromous fish. PacifiCorp would also be required to file annual reports to the Commission that would describe actions taken in the past year, provide a summary of monitoring studies conducted to date, and describing actions proposed for the next year. A draft of each annual report would be distributed to the advisory committee for comment, and the final report filed with the Commission would include copies of agency comments on the plan and describe how these comments were addressed in the final report. Any proposed actions would be implemented by PacifiCorp following the Commission's approval.

Our assessment of the number of spawning fall Chinook salmon that could be accommodated in each project reach by implementing effective fish passage for anadromous fish to habitat within the project area is provided in table 3-77. We conclude that there is not sufficient information in the record to estimate potential returns for other anadromous species or for habitat upstream of Upper Klamath Lake. Although it appears that the greatest near-term restoration potential exists for fall Chinook salmon, there is substantial potential for increased production of other anadromous species, especially if ongoing habitat restoration efforts continue. It is likely that these efforts would accelerate with the reintroduction of anadromous species.

Table 3-77. Estimated habitat capacity for adult fall Chinook salmon in the Iron Gate to Copco No. 2 dam, Copco No. 1 to J.C. Boyle, and J.C. Boyle to Keno reaches. (Source: Staff)

Location	Habitat Capacity (adult fish)[a]	Basis
Iron Gate to Copco No. 2 dam		
Fall Creek[b]	300	Coots (1957) estimated that Fall Creek can support 300 spawners in the accessible 1.1 miles of stream.
Jenny Creek[b]	250	Coots and Wales (1952) estimated that 250 Chinook spawned in the 0.9 miles of accessible stream in 1952.
Copco No. 2 bypassed reach	600	Coots and Wales (1952) estimated that 300 Chinook spawned in the 1.4-mile long bypassed reach in 1952 at an observed flow of 8 cfs. They noted that "a large portion of the spawning areas appeared unused." With sediment augmentation and increased minimum flows, we estimated that the reach could support 600 spawners, which equates to 428 spawners per mile.
Reach Total	**1,150**	
Copco No. 1 to J.C. Boyle dam		
Shovel Creek	937	Huntington et al. (2006) reports that Shovel Creek has 3.3 miles of usable habitat. Using the average spawner density of 284 fish per mile observed by Coots and Wales (1952) in Jenny and Fall Creeks, we estimate that Shovel Creek could support about 937 spawners.
Long Pine Creek	213	Olsen (2006) reports that Long Pine Creek has about 0.75 miles of usable habitat. Using the average spawner density of 284 fish per mile observed by Coots and Wales (1952) in Jenny and Fall Creeks, we estimate that Long Pine Creek could support about 213 spawners.
J.C. Boyle peaking reach	3,702	To account for high gradient and limited spawning gravel, we used half of the spawner density used for the Copco No. 2 bypassed reach. Based on a stream length of 17.3 miles and 214 spawners per mile, we estimate that the peaking reach could support about 3,702 spawners.
J.C. Boyle bypassed reach	920	To account for high gradient and limited spawning gravel, we used half of the spawner density used for the Copco No. 2 bypassed reach. Based on a stream length of 4.3 miles and 214 spawners per mile, we estimate that the bypassed reach could support about 920 spawners.
Reach Total	**5,772**	

Location	Habitat Capacity (adult fish)[a]	Basis
J.C. Boyle to Keno dam		
Spencer Creek	4,175	Huntington et al. (2006) reports that Spencer Creek has 14.7 miles of usable habitat. Using the average spawner density of 284 fish per mile observed by Coots and Wales (1952) in Jenny and Fall Creeks, we estimate that Spencer Creek could support 4,175 spawners.
Keno reach	0	Assumed to be water quality limited
Reach Total	**4,175**	

[a] These estimates are based on adult returns or estimates of habitat capacity from the indicated sources. We note that future adult returns would be dependent on many factors, including current habitat conditions, passage survival, disease effects, harvest management, and ocean conditions.

[b] Habitat capacity estimates for Jenny and Fall creeks have not been adjusted for inundation of some accessible habitat by Iron Gate reservoir, and may be substantially lower than indicated, unless Iron Gate dam is removed.

We see several practical limitations to the restoration approach described in the Klamath Tribe's restoration plan and 10(a) recommendations. First, if the license is denied and the four lower dams are removed within 5 years, the dam sites would not fall under the Commission's jurisdiction and the Commission would have no authority to require fish restoration efforts at them. In addition, the continued operation of Iron Gate Hatchery would not be possible due to the loss of the cool water supply that is provided from Iron Gate reservoir. At this time there is insufficient information to support a conclusion that dam removal would completely resolve water quality and disease-related mortality of fall Chinook salmon in the lower Klamath River, and without reducing these losses the fall Chinook salmon runs in the entire basin could continue to decline. Finally, measures that may be required to restore anadromous fish to habitat upstream of the project would likely involve the restoration of habitat and water quality conditions that have not been affected by the project, and it would not be appropriate to require PacifiCorp to be responsible for those activities.

3.3.3.2.6 Iron Gate Hatchery Operations

Cal Fish & Game operates Iron Gate Hatchery, and PacifiCorp funds 80 percent of the total operating costs to satisfy its annual mitigation goals for fall Chinook salmon fingerlings, coho salmon yearlings, and steelhead yearlings. All adult steelhead processed in the hatchery are returned to the Klamath River, and all juvenile salmon and steelhead that are produced are released directly into the Klamath River from the hatchery. Maintaining genetic diversity by distributing the egg allotment throughout the spawning run takes precedence over meeting numeric production goals.

The hatchery production supports recreational and commercial fisheries in the Klamath River Basin and the Pacific Ocean, and current hatchery production goals are presented in table 3-53. Beginning in 1979, portions of the fall Chinook salmon fingerling production have been reared to the yearling stage for release in November in order to reduce potential interactions with wild fish in the lower river in June. The Chinook salmon yearling program is funded entirely by Cal Fish & Game; although since 2004 funding for this program has not been available. Furthermore, no yearlings were released in 1997 or 1998. When there is no yearling production, the number of smolts released is increased.

Current production at Iron Gate Hatchery maximizes use of the facilities, with six of eight raceways dedicated to Chinook salmon production, and one each for coho salmon and steelhead. In years when Cal Fish & Game funds Chinook salmon yearling production, the Fall Creek rearing facility is used for rearing approximately 200,000 fall Chinook salmon to the yearling stage, with survival to release typically 180,000 fish at 8 fish/lb. Water used to support current production at Iron Gate comes from high

and low-level intakes at Iron Gate reservoir, and from late spring through early fall, water for the raceways and upper ladder is supplied from the 70-foot deep intake at Iron Gate. This supply of cool water from below the thermocline is limited, and in some years is depleted by late summer, to the extent that warm water temperatures have caused substantial mortalities of adult Chinook salmon in the pre-spawning holding ponds (PacifiCorp, 2005k). At the Fall Creek rearing facility, Cal Fish & Game diverts and uses 6 to 9 cfs from the Fall Creek powerhouse tailrace channel. Flows are returned back to Fall Creek.

PacifiCorp proposes to maintain their current obligation to fund 80 percent of the annual O&M costs for production and operation of Iron Gate Hatchery. It also proposes to fund minor upgrades at Iron Gate Hatchery, although no details of the upgrades were provided.

Currently, about 5 percent of Chinook salmon produced at Iron Gate Hatchery are tagged with coded wire tags and marked with an adipose fin clip. Cal Fish & Game funds the marking (fin or maxillary clip) of all coho salmon (75,000 released annually since 1996) and all steelhead (200,000 released annually since 1998). PacifiCorp proposes to purchase and construct a mass-marking facility at Iron Gate Hatchery to enable tagging 25 percent of released fall Chinook salmon. This measure would fund annual tagging operations including labor, equipment, and tagging materials.

The Klamath Tribes recommend PacifiCorp continue funding for O&M of Iron Gate Hatchery and bring hatchery management up to standards appropriate for a conservation hatchery, as determined by a hatchery technical advisory group. NMFS and Cal Fish & Game recommend that PacifiCorp fund 100 percent of hatchery annual operating costs,[91] facility improvements, new construction, fish marking, monitoring and recovery costs, and any permits and plans required by state or federal agencies. NMFS further recommends the hatchery facilitate implementation of fish passage measures to restore wild runs of anadromous and resident fish above and below the project. The Klamath Tribes recommend PacifiCorp fund a group of state, federal and tribal technical experts to provide recommendations and guidance to fisheries' managers to maximize the use of Iron Gate Hatchery for anadromous salmonid restoration and management efforts on portions of the Klamath River Basin affected by the project.

NMFS, FWS, Cal Fish & Game and the Forest Service recommend that PacifiCorp consult with agencies to develop a hatchery and genetics management plan (HGMP) for Iron Gate Hatchery operations that includes (1) an accurate adult census of natural salmonids; (2) determination of the rate and contribution of hatchery strays to natural spawning stocks; (3) determination of the rate of competition between hatchery and natural salmonids; (4) determination of genetic characteristics of natural and hatchery coho salmon and steelhead stocks; (5) determination of outmigration timing of hatchery and natural stocks; (6) maintenance of tribal trust and resource trustee obligations to mitigate for lost habitat; (7) development of conservation hatchery techniques; and (8) minimization of any negative effects from fish husbandry or juvenile releases on native, naturally occurring populations of listed salmonids.

The Forest Service recommends PacifiCorp be responsible for marking 25 percent of all Chinook salmon releases. Cal Fish & Game recommends PacifiCorp fully fund marking 25 percent of all Chinook salmon released, allowing for adjustment to the marking rate as new technologies are developed or deemed appropriate in consultation with agencies and affected tribes. FWS recommends PacifiCorp be responsible for marking 25 percent of all Chinook salmon releases and 100 percent of all coho salmon releases. NMFS recommends PacifiCorp be responsible for tagging 100 percent of all hatchery-released Chinook salmon.

Siskiyou County recommends the Commission consider the scientific questions around "wild fish" production versus "hatchery fish" production. They state they understand the goal of favoring wild

[91]Cal Fish & Game states that Fall Creek rearing facility operations are integral to Iron Gate Hatchery, and incorporates Fall Creek in all its recommendations for Iron Gate Hatchery.

fish populations over hatchery fish to be federal and state fisheries agency policy; however, they request resolution of the question of "…when hatchery fish are or are not the "same" as wild fish."

As discussed in section 3.3.3.2.5, *Anadromous Fish Restoration*, PacifiCorp included several hatchery measures in its December 1, 2006, alternative fishway prescription, including providing hatchery compensation if upstream passage survival rates of less than 95 percent are observed, funding 100 percent of the marking of fish produced at Iron Gate Hatchery, and reducing hatchery production over time according to the number of juvenile fish that are produced upstream of Iron Gate dam.

Our Analysis

Production from Iron Gate Hatchery contributes to commercial, tribal, and recreational fisheries in the Klamath River Basin and the Pacific Ocean. In the mixed-stock coastal fisheries of the Pacific Ocean, the presence of hatchery fish allows for higher harvest levels than if there were no hatchery stocks in the fishery. PacifiCorp's proposal and the agency's recommendations to continue to produce fish from the Iron Gate Hatchery would provide fish to support these fisheries. However, because wild fish are harvested along with hatchery fish in coastal commercial and recreational fisheries, an increase in allowable harvest may also affect the escapement of wild stocks when these fish are harvested along with hatchery fish.

Hatchery production can benefit natural stocks of salmonids by increasing their population and conserving genetic strains of populations that are at risk of extinction. Hatchery production may also have an adverse effect on natural populations through behavioral differences that result in diminished fitness and survival of hatchery fish relative to naturally spawned fish, genetic effects resulting from poor broodstock and rearing practices, and increased competition with and predation on naturally spawned populations (NMFS, 2006). At Iron Gate Hatchery, wild spawners are commonly integrated into the hatchery egg take to minimize genetic digression between hatchery and wild stocks.

PacifiCorp (2005k) evaluated several alternatives for increasing production of Chinook salmon yearlings at Iron Gate Hatchery. The rationale for producing fewer Chinook salmon smolts and replacing the production with more yearling Chinook salmon is to lessen competition for space and food resources in the lower river during the spring and summer when most wild Chinook salmon smolts are migrating. Available space for outmigrating smolts during late spring and summer is often limited to thermal refugia. As the water temperature warms, smolts of wild and hatchery origin crowd into such habitat creating stressful conditions. Stress from crowding can result in mortality from a variety of causes, including increased susceptibility to disease, as discussed in section 3.3.1.4, *Diseases Affecting Salmon and Steelhead*. In addition to funding the yearling fall Chinook salmon program in past years, Cal Fish & Game implemented an early release strategy starting in 2001 to reduce crowding of smolts in thermal refugia late in the migration season. Instead of releasing subyearling Chinook salmon smolts between June 1 and June 15 as was previously done, smolts are now released in four groups beginning in May (Hampton, 2005).

Production scenarios evaluated by PacifiCorp include continuing existing production levels (Alternative 1), replacing a portion of the current Chinook salmon subyearling smolt production with the equivalent weight of yearling production (Alternative 2), producing all Chinook salmon at the hatchery to yearling stage (Alternative 3), modifying Alternative 2 to include producing spring Chinook salmon (Alternative 4), and converting all hatchery production to yearling Chinook salmon and eliminating all coho salmon and steelhead production (Alternative 5).

The scenarios evaluated by PacifiCorp assume the total pounds of fish produced at Iron Gate Hatchery remain approximately the same as current production due to limitations of the existing water supply. As previously discussed, water used to support current production at Iron Gate comes from high and low-level intakes at Iron Gate reservoir, and from late spring through early fall, water for the raceways and upper ladder is supplied from the 70-foot deep intake at Iron Gate. This supply of cool

water from below the thermocline is limited, and in some years is so depleted by late summer that warm water temperatures have caused substantial mortalities of adult Chinook salmon in the pre-spawning holding ponds (PacifiCorp, 2005k). For this reason PacifiCorp did not evaluate expansion of capacity at Iron Gate Hatchery when evaluating Alternatives 2 through 5.

For the Fall Creek rearing facilities, PacifiCorp assumes a 12 cfs minimum flow would be maintained in Fall Creek.[92] Existing stream flow in Fall Creek is typically about 40 cfs, and the city of Yreka maintains a water right for 15 cfs. Therefore, 40 cfs less the 15 cfs water right less the 12 cfs minimum flow would leave 13 cfs available for hatchery uses. The existing facility uses 6 to 8 cfs when operational (PacifiCorp indicated this could possibly be reduced to 4 cfs), therefore 5 to 7 cfs of flow would potentially be available for new facilities, assuming no additional water supplies could be identified. If water used by the existing hatchery could be reused at a new downstream facility, then up to 13 cfs could be available.

The production totals evaluated in Alternatives 2 through 5 are limited by the estimated water supply available from Fall Creek. PacifiCorp assumes increasing yearling production under Alternatives 2 and 3 would require an additional facility be constructed at Fall Creek[93] to accommodate rearing an additional 300,000 yearling fish, and would use approximately 6.2 cfs and 8.4 cfs, respectively from Fall Creek. PacifiCorp estimates Alternative 4 would require new facilities that use 5.4 cfs of flow, and Alternative 5 would require an estimated 6.2 cfs of flow from Fall Creek.

Currently, production at Iron Gate Hatchery is at full capacity based on available water supplies. Therefore, without increasing capacity, a shift to produce more yearlings would substantially reduce the number of subyearling smolts that could be produced. Based on its analysis of alternatives 1 through 3, PacifiCorp concluded that shifting towards yearling production would decrease total returns of adult fall Chinook salmon to the hatchery.[94] PacifiCorp assumed in its analysis that subyearling smolts would have an adult return rate of 1 percent and yearling smolts would have an adult return rate of 3 percent.

Recent returns of Chinook salmon to Iron Gate Hatchery indicate that adult return rates are highly variable, especially for fish that were released as subyearling smolts. In a comparison of subyearling and yearling return rates for fall Chinook salmon releases for 1990-1996 and 1999-2000, Hampton (2005) found that return rates of subyearlings were 0.05 percent or less in four out of 9 years evaluated (table 3-78). Furthermore, preliminary data from the 2001 brood year indicated that only 181 out of 3,149 adults that returned as age 3+ fish in 2004 were from subyearling releases. Hampton (2005) concluded that low flow conditions that occurred during the spring of 2002 when the 2001 brood year emigrated from the river, and the lack of substantial scouring flows in the preceding 2 years, may have contributed to high losses from disease during the spring outmigration. He also noted subyearling smolts from the 1992 brood year may have benefited from high flows that occurred during the spring outmigration period, and that this is the only brood year where the return rate of subyearling smolts exceeded the adult return rate for fish that were released as yearlings (table 3-78).

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[92]In its alternatives analysis, PacifiCorp assumes a minimum instream flow of 12 cfs. In its license application, it proposes a 15 cfs minimum flow release for Fall Creek.

[93]PacifiCorp assumes the existing Fall Creek rearing facility is used to capacity to rear 180,000 fall Chinook yearlings.

[94]PacifiCorp estimates Alternative 1 through 3 fall Chinook adult returns at 81,400; 61,400; and 44,640 fish, respectively (PacifiCorp, 2005k).

Table 3-78. Ratio of coded-wire tagged Chinook salmon subyearling and yearling smolt release return rates (percent) to Iron Gate Hatchery and water-year types. (Source: Hampton, 2005; Reclamation, 2003; adapted by staff)

Brood Year[a]	Return rate of tagged subyearlings (%)	Return rate of tagged yearlings (%)	Ratio yearling/ sub-yearling returns	Average monthly flow (cfs) in year of outmigration (brood year plus 1)	
				May	June
1990	0.38	0.77	2.04	874	677
1991	0.05	0.18	3.66	513	506
1992	0.55	0.36	0.66	2,677	2,408
1993	0.03	0.20	9.42	727	704
1994	0.05	0.52	10.84	3,251	1,073
1995	0.04	1.06	23.87	3,279	1,532
1996	0.08	0.61	7.39	2,104	1,243
1999	0.38	0.56	1.5	2,282	1,334
2000	0.14	0.67	4.65	1,726	1,897
AVG	**0.19**	**0.55**	**7.11**	**1,937**	**1,263**

[a] There were no yearling releases in 1997-1998 due to funding limitations.

The highly variable return rates observed for subyearling smolt releases indicates that pursuing a more balanced strategy of releasing both subyearling smolts and yearling fall Chinook salmon may provide more consistent adult returns, and help to prevent a severe decline if several years of poor spring migration conditions were to occur in a row. As discussed in section 3.3.3.2.3, *Disease Management*, there appears to be a trend towards increased losses of subyearling juvenile fall Chinook salmon from disease, with mortality rates exceeding 70 percent in the last half of the outmigration in both 2004 and 2005. Releasing a substantial portion of hatchery-produced fall Chinook salmon as yearlings, which are released in November when water quality conditions are more favorable, would reduce the potential for hatchery fish to be exposed to disease, consequently reducing the potential for a corresponding severe decline in adult returns.

The recommendations by the Klamath Tribes, NMFS, FWS, and Cal Fish & Game to develop a hatchery genetics management plan in consultation with an advisory committee would provide a structure for ongoing analysis of hatchery programs and recommendations for future management of hatchery production. HGMPs are described in NMFS's final salmon and steelhead 4(d) rule (July 10, 2000, 65 FR 42422) as a mechanism for addressing the take of certain listed species that may occur as a result of artificial propagation activities. In the draft EIS, we concluded that development and implementation of a HGMP should be the responsibility of Cal Fish & Game, because it manages and operates the hatchery and fisheries on the stocks that are produced at the hatchery. However, in its comments on the draft EIS, NMFS clarified its position that it views development and implementation of a hatchery and genetic management plan to be required to continue operation of the hatchery in compliance with the ESA. We maintain that PacifiCorp should not be required to assume responsibility for collecting information that is needed primarily for fisheries management purposes. Among the eight components identified above, items 1 (adult census of natural salmonids), and 2 (determination of the rate and contribution of hatchery strays to natural spawning stocks) fall into this category.

PacifiCorp proposes, and FWS and Cal Fish & Game recommend marking 25 percent of hatchery-released Chinook salmon. Such marking can help reduce harvest mortality on wild Chinook salmon through implementation of harvest restrictions on unmarked fish. Marking hatchery fish, including coho salmon and steelhead, would aid recovery and harvest management programs by enabling an assessment of the relative contribution of hatchery and natural production of these fish in the ocean and inland harvests, in-river spawning escapements, straying rates, and hatchery returns. Marking hatchery fish can also aid in distinguishing the origin of fish that may be re-introduced to spawn in habitats upstream of Iron Gate dam.

Marking only a portion of the fish released would make it impossible for fishermen to distinguish non-clipped hatchery fish from wild fish. Furthermore, if selective harvest restrictions were in place to protect natural spawners, this could reduce the amount of catch that may otherwise be available for harvest. Marking 100 percent of hatchery fish released would avoid that occurrence. The ability of fishermen to distinguish coho salmon of hatchery origin, which are not protected under the provisions of the ESA, from those of wild origin, which are protected under the ESA, would avoid inadvertent takings of federally listed salmon. The ability of recreational fishermen to distinguish Klamath fall Chinook salmon of hatchery origin from those of wild origin, whose harvest is regulated under the terms of the Pacific Salmon Management Plan, would allow for targeted fisheries on hatchery stocks in years when all harvest of Klamath Chinook salmon may be prohibited, as they are in 2006.

Siskiyou County requests that the Commission require resolution of the question of "…when hatchery fish are or are not the "same" as wild fish." In a review of 18 studies estimating relative fitness of hatchery and natural anadromous salmonids, Berejikian and Ford (2004) find that the literature on genetic introgression of hatchery and natural populations is inconclusive. They find that variables such as intensity and duration of stocking efforts, genetic similarity of hatchery and natural stocks, habitat quality, selective fisheries, and other factors make it difficult to ascertain relative fitness between stocks. Although relative fitness is only one aspect of whether hatchery fish are the same as wild fish, these results illustrate that resolving this question requires much more study. Conducting such research falls outside the purview of the Commission, and more appropriately rests with the fisheries scientists and management agencies.

3.3.3.2.7 Habitat Enhancement

PacifiCorp proposes to modify irrigation diversions associated with its Copco Ranch (a non-hydro related property) to reduce entrainment of trout fry and to increase instream flows. It proposes to replace unscreened gravity-fed diversions in the J.C. Boyle peaking reach with screened pump systems and to eliminate existing diversions on Shovel Creek and its tributary, Negro Creek.

Siskiyou County recommends that PacifiCorp fund about $26 million of programs over the next 5 to 10 years. These programs, as identified by the Shasta Valley and Siskiyou Resource Conservation districts, focus on (1) maintaining connectivity to ensure juveniles can emigrate from the tributaries to the mainstem and from the mainstem or lower portion of the tributaries upstream to suitable habitat; (2) habitat improvement programs that focus on minimizing the effects on riparian areas, ensuring adequate flows, and addressing temperature-related issues; (3) water quality programs that focus on implementing riparian planting projects to increase shade needed to cool water temperatures; (4) water supply improvement programs that enhance stream flows; and (5) monitoring and assessment programs. In its comments on the draft EIS, Siskiyou County reduced its funding request to approximately $18 million.

NMFS and FWS recommend that PacifiCorp develop habitat protection, mitigation, and enhancement plans to mitigate for effects on upstream and downstream migrating anadromous fish (FWS also includes effects on migrating federally listed suckers). The plans would include (1) assessing the effectiveness of all upstream and downstream fish passage facilities; (2) evaluating the survival of upstream and downstream migrating fish; (3) identifying fish protection, mitigation, and enhancement measures such as modifications of project facilities and operations to maximize the efficiency of fishway operations, including reservoir elevations and flows, and predator and predation control; and (4) implementing the measures and monitoring to ensure their effectiveness.

Oregon Fish & Wildlife recommends that PacifiCorp develop and implement a fish and wildlife habitat restoration resource management plan. The plan would entail an annual compilation of information summarizing progress towards restoring fish and wildlife habitat below, within, and above the project. The plan would be updated every 5 years in consultation with stakeholders. Annual reports would include a work plan for the upcoming year, a report on actions that were implemented in the

previous year, and a monitoring and compliance report. Oregon Fish & Wildlife recommends that stakeholders be provided a minimum of 60 days to review and comment on all plans and actions, and that consultation be documented in each plan or report that is submitted to the Commission.

NMFS, FWS, Cal Fish & Game, Oregon Fish & Wildlife, and the Hoopa Valley Tribe recommend that PacifiCorp develop plans to restore habitat above and below the project to mitigate for continued, ongoing, and cumulative project effects. The plans would be developed to compensate for project effects on (1) 5 miles of bypassed channel at the J.C. Boyle and Copco No. 2 developments; (2) 14.2 miles of riverine channel inundated by project reservoirs; and (3) any other continued effects on anadromous fish that are not avoided in future operations, including fish passage facilities that are not 100 percent effective. Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend that the plans include projects that enhance and improve wetlands, riparian and riverine habitat, and riparian, aquatic, and terrestrial species connectivity, including measures such as habitat restoration projects, instream flow and water quality restoration, and land acquisition. FWS and NMFS recommend that the plan include measures on Forest Service and Bureau of Land Management lands on Jenny, Fall, Spencer, and Shovel creeks, including measures identified in the Spencer Creek Pilot Watershed Analysis. Measures identified by FWS and NMFS include cooperative funding with water users to improve fish passage at irrigation diversions or other constructed barriers in the upper basin and purchase of instream water rights. Cal Fish & Game recommends that PacifiCorp identify and fund aquatic and riparian habitat monitoring and enhancement measures in mainstem reaches and tributaries to mitigate for flow-related effects.

Our Analysis

PacifiCorp's proposal to modify irrigation diversions associated with its Copco Ranch would reduce the entrainment of trout fry from the mainstem diversions in the peaking reach and from Shovel and Negro creeks, which provide an important spawning area for trout in the California section of the peaking reach. Eliminating diversions on Shovel and Negro creeks would increase minimum flows in Shovel Creek by about 15 cfs, further increasing the production potential from these tributaries. These tributaries and the bypassed reach provide the only substantial spawning areas that are available to trout residing in the 17.3-mile-long peaking reach and 4.5-mile-long bypassed reach. Access to spawning habitat for trout residing in the J.C. Boyle peaking reach has been reduced by the interruption of sediment transport, inundation of spawning habitat by J.C. Boyle reservoir, and the lack of effective passage at J.C. Boyle dam.

We do not have enough information to evaluate the potential benefits of the enhancement plans recommended by NMFS, FWS, Cal Fish & Game, Oregon Fish & Wildlife, and the Hoopa Valley Tribe. Although these parties provide some idea of measures that might be considered, they provide no specific details on how such measures would be implemented, where they would occur, how closely associated they would be with project-related effects, or what benefits they would provide. It is most appropriate to address identified project-specific effects with specific protection and enhancement measures that address those effects, rather than considering general types of protection or enhancement measures that may not clearly connect to project purposes. It is not appropriate to require PacifiCorp to collect and compile information on restoring fish and wildlife habitat upstream of the project, as several entities recommend, without specific measures and a nexus to the project.

Siskiyou County's recommendation that PacifiCorp fund programs to enhance flows and reduce water temperatures in Klamath River tributaries has the potential to benefit anadromous fish that spawn and rear in the tributaries, and also to improve water quality conditions in the mainstem Klamath River and may contribute to alleviating disease-related losses. In section 3.3.3.2.3, *Disease Management*, we include these types of measures in our listing of measures that could be included in a disease monitoring and management plan. The potential benefits of all disease management approaches can be most effectively considered in a single coordinated plan that would allow the most effective combination of approaches to be selected for implementation.

In section 3.3.3.2.5, *Anadromous Fish Restoration*, we evaluate the development of a reach-specific anadromous fish restoration plan, which would focus on initially restoring anadromous fish passage and habitat conditions in a single reach upstream of Iron Gate, Copco No. 1, or J.C. Boyle dam (with the potential for including additional project reaches in the restoration effort at a later time). The reach would be selected based on the results of radio telemetry monitoring of adult fall Chinook salmon and of juvenile production conducted over a 3-year evaluation period. The restoration plan would evaluate potential methods for providing fish passage, and the need for habitat enhancement measures such as spawning gravel augmentation or operational changes that are needed to support restoration efforts. The plan would be developed in consultation with the management agencies and tribes, and filed with the Commission for approval. We anticipate that the plan would be developed in the fourth year after license issuance, and implemented over a 5-year period.

In section 3.3.1.2.3, *Project Effects on Sediment Transport*, we describe in detail and evaluate measures proposed by PacifiCorp and recommended or prescribed by agencies to augment the supply of spawning gravel in project-affected reaches. PacifiCorp proposes an initial placement of 100 to 200 cubic yards of gravel in the J.C. Boyle bypassed reach and an initial placement of 1,755 to 3,510 cubic yards of gravel between Iron Gate dam and the Shasta River, with the volumes and frequencies of recurring sediment augmentation to be determined based on the results of monitoring. Agency recommendations include assessing and addressing gravel needs in all project-affected reaches, and the Bureau of Land Management specifies the annual placement of between 1,226 and 6,134 tons (826 to 4,131 cubic yards) of gravel each year in the J.C. Boyle bypassed and peaking reaches.

PacifiCorp reports that the availability of suitably sized spawning gravel is very limited in the J.C. Boyle bypassed and peaking reaches, and we conclude that the abundance of gravel in these reaches has likely been reduced due to gravel being trapped in J.C. Boyle reservoir. The addition of gravel to the J.C. Boyle bypassed reach would increase the availability of spawning habitat and likely lead to increased recruitment of trout to the bypassed and peaking reaches. In addition, gravel that is transported from the bypassed reach during high flow events would provide some improvement in potential spawning habitat in the peaking reach. To assess the potential benefit to trout populations, we estimate that, if 2,000 cubic yards of gravel was introduced (10 years of augmentation at a rate of 200 cubic yards per year), this would be sufficient to cover 18,000 square feet of stream bed at an average depth of 1 foot. Assuming an average of space requirement of 8 square feet of spawning area per redd,[95] this area of gravel could accommodate approximately 6,200 trout redds. Because much of the gravel may be transported downstream or deposited in areas that do not have appropriate depths or velocities to support spawning, we estimate that the actual number of redds that could be accommodated would probably be on the order of 1,000 to 2,000. Because of its high gradient and the greater magnitude of flow fluctuations that occur in the downstream peaking reach, gravel placed in the peaking reach would be likely to be transported downstream more rapidly and would provide less benefit to trout spawning than gravel that is placed in the bypassed reach.

The reach below Iron Gate dam is heavily used by spawning fall Chinook salmon, and the availability of spawning-sized gravel in this reach has probably been affected by the interruption of gravel transport by Iron Gate and the other project dams. Augmenting gravel in this reach would increase the quantity of available spawning habitat, and as we discuss in section 3.3.3.2.3, *Disease Management*, increasing the supply of gravel would increase substrate mobility and help to reduce the accumulation of attached algae that provides habitat for the polychaete intermediate host for two important disease pathogens. We estimate that if 35,000 cubic yards of gravel was introduced (10 years of augmentation at a rate of 3,500 cubic yards per year), that this would be sufficient to cover 945,000 square feet of stream

[95]This is based on an average redd area of 0.8 square foot given in Bjornn and Reiser (1991), and an assumed total space requirement of five times that area based on the area per spawning pair recommended for salmonid species by Bjornn and Reiser (1991).

bed at an average depth of 1 foot. Assuming an average requirement of 220 square feet of spawning area per redd,[96] this area of gravel could accommodate approximately 4,300 fall Chinook salmon redds. Because fall Chinook salmon spawn over at least 100 miles of the lower Klamath River, this gravel would remain accessible to spawning salmon for a considerable number of years before it was transported from the reach. However, because some gravel would be transported to and deposited in areas that do not have appropriate depths or velocities to support spawning, we estimate that the actual number of redds that could be accommodated would probably be on the order of 1,000 to 3,000.

3.3.3.2.8 Monitoring and Adaptive Management

Monitoring

Monitoring the effects of environmental measures that are included in a new license helps to ensure that the measures are effective, and it affords the opportunity for measures to be modified, if needed, to meet resource management goals. Numerous stakeholders provided recommendations related to monitoring fisheries and aquatic habitat, reporting monitoring results to stakeholders, and implementing adaptive management. We describe and evaluate these recommended measures in the following section.

PacifiCorp does not propose any specific monitoring or adaptive management measures for aquatic resources.

FWS recommends that PacifiCorp develop and implement an aquatic habitat monitoring plan to monitor the effectiveness of implementation of license conditions that improve quality and quantity of aquatic habitat for resident, migratory, and anadromous fish within project reaches, and to apply adaptive management, as needed. Annual reports, which would be provided to a Fisheries Technical Subcommittee, would include monitoring data and PacifiCorp's conclusions on the state of aquatic habitat including the adequacy of flows for supporting aquatic and riparian resources and providing opportunities for recreation. Components would include monitoring habitat condition and habitat productivity at 5-year intervals and spawning habitat and habitat connectivity at 3-year intervals. The plan would include details of methods, implementation strategies, procedures for adjusting monitoring strategies, reporting, and how adaptive management principles would be applied.

FWS recommends that PacifiCorp develop and implement a plan to monitor resident fish populations every 3 years to include (1) monitoring the distribution, population structure, and abundance of resident fish populations, including federally listed suckers (using protocols of Markle et al. [2000] and Simon et al. [1995], for larvae, juvenile, and adult suckers) in all project reservoirs and reaches below Keno dam; and (2) monitoring the number, size, and sex of spawning rainbow trout in important project reach tributaries including Scotch, Camp, Jenny, Fall, Shovel, Long Prairie, and Spencer creeks.

Oregon Fish & Wildlife recommends that PacifiCorp develop and implement an aquatic monitoring plan for the J.C. Boyle bypassed and peaking reaches, including provisions to monitor fish populations and habitat to assess the effectiveness of implementation of measures that pertain to flow, ramp rates, and sediment augmentation. The plan would include an adaptive management strategy that addresses changes and proposed actions for meeting resource goals for restoration of fish and aquatic life in the J.C. Boyle bypassed and peaking reaches. Every 5 years, PacifiCorp would consult with stakeholders to review and revise monitoring strategies based on new information.

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[96]This is based on an average redd area of 20.4 square feet given in Bjornn and Reiser (1991), and an assumed total space requirement of five times that area based on the area per spawning pair recommended for salmonid species by Bjornn and Reiser (1991).

Oregon Fish & Wildlife recommends that PacifiCorp develop and implement an aquatics monitoring resource management plan. The plan would include provisions for implementing monitoring activities associated with restoring aquatic fish population productivity including fish health and condition, fish habitat condition, reach productivity (bioenergetics), population structure (age distribution, sex rations, species assemblages), spawning populations, and fish migration and movement. The plan would be updated every 5 years in consultation with stakeholders. Annual reports would include a work plan for the upcoming year, a report on actions that were implemented in the previous year, and a monitoring and compliance report. The plan also would include provision for preparing a tri-annual aquatics monitoring report that describes monitoring efforts over the previous 3 years; information on compliance with license conditions relating to instream flow, ramp rate, and sediment augmentation; and reporting any unusual events or conditions that may have affected fish and aquatic resources during the previous 3 years. Oregon Fish & Wildlife recommends that stakeholders be provided a minimum of 60 days to review and comment on all plans and actions, and that consultation be documented in each plan or report that is submitted to the Commission.

Oregon Fish & Wildlife's J.C. Boyle aquatic monitoring plan is similar to its proposed fish monitoring resource management plan, but the recommendation provides different monitoring frequencies for some elements and greater detail on the elements that would be included. The results of fish health monitoring would be reported annually, monitoring of fish habitat condition and reach productivity would occur every 5 years, and population structure, spawning populations, and fish migration and movement monitoring would occur every 3 years. Monitoring of fish health would include monitoring for fish disease and of fish condition for salmonids in the bypassed and peaking reaches. Fish habitat condition monitoring would include surveys to identify new spawning areas; substrate composition, particle size, and degree of embeddedness; and changes in areal extent of riparian vegetation and riparian species cover. Reach productivity would include monitoring of bioenergetics using methods described in Addley (2003). Population monitoring would include monitoring changes in the distribution, annual growth, population structure (age distribution, sex ratios, species assemblages), and abundance of resident and anadromous fish populations, using specific sampling protocols for monitoring of larvae, juvenile, and adult suckers. Monitoring of spawning populations would include the number, size, and sex of spawning rainbow trout and anadromous salmonids spawning in the Klamath River Project reaches, identification of potential spawning areas identified by habitat surveys, and testing of the proportion of resident and anadromous forms of rainbow trout in tributary streams at 3, 7, and 15 years after reintroduction of anadromous fish. Monitoring of fish migration and movement would include monitoring of native fish populations for effects of flow alteration on feeding behavior, possible delayed migration between the peaking and bypassed reaches, and survival.

The Forest Service recommends that PacifiCorp model and monitor integrated project effects, including hatchery operations, on the anadromous fish populations downstream of Iron Gate dam. Results would be used to reduce effects on fish, especially wild stocks, through adaptive management.

NMFS and FWS recommend that PacifiCorp develop and implement an anadromous fish monitoring plan that describes protocols for (1) estimating the number, size, sex, timing, survival, and origin of anadromous fish returning to Iron Gate dam by using a combination of PIT tags and fish marked in other ways; (2) estimating the spawning populations of each species of anadromous fish in key tributaries within the project area; (3) estimating the numbers of juvenile outmigrant Chinook salmon originating from the same key tributaries within the project area; and (4) implementing measures recommended by the agencies to meet project passage goals. Both agencies recommend estimating juvenile outmigrants every third year. NMFS recommends estimating spawning populations every 3 years, while FWS recommends annual estimates.

Our Analysis

Development of a habitat and fish population monitoring plan would help to ensure that measures included in a new license are effective and would help to identify any modifications that are needed to meet resource management goals. Conducting fish population assessments would assist with monitoring progress in restoring anadromous fish species and to determine responses of resident fish populations to changes in project operations and other environmental measures including gravel augmentation in the J.C. Boyle bypassed reach and screening of irrigation diversions in Shovel and Negro creeks. Monitoring the location and usage of spawning habitat in the J.C. Boyle bypassed and peaking reaches would help to determine whether the quantity and location of gravel placement requires any adjustment to ensure that a sufficient amount of habitat is available to support salmonid spawning.

We see no reason why fish population monitoring would need to be continued at 3-year intervals over the term of the license. Three cycles of monitoring fish populations in project reservoirs and reaches at 3-year intervals should provide a sound basis for considering whether any additional adjustments in project operations or other measures are warranted, and the frequency at which monitoring would be conducted in the future could be re-evaluated at that time.

In the draft EIS, we concluded that monitoring populations of listed sucker species in project reservoirs every third year, as recommended by Interior, was not justified due to the long life-span of the species and the lack of proposed measures or changes in operations that could be expected to affect sucker populations. However, the integrated fish passage and disease management program that we include in the Staff Alternative includes two measures that could affect reservoir populations of suckers: (1) installation of a screening facility at J.C. Boyle (which would affect the downstream recruitment of juvenile suckers), and (2) an experimental drawdown of Copco and Iron Gate reservoirs to evaluate effects on smolt migration, downstream water quality, and pathogen density. Monitoring sucker populations in project reservoirs at 3-year intervals for the first 9 years would provide information on the effects of these measures on reservoir fish populations, and could help to guide decisions on where listed suckers collected at the screening facility should be released.

We see little benefit in monitoring the number, size, and sex of spawning rainbow trout in Scotch, Camp, Shovel, Long Prairie, and Spencer creeks, as FWS recommends, because spawning habitat in these creeks is not affected by project operations. However, periodic population sampling in Jenny and Fall creeks would enable the effects of project operations on trout in these tributaries to be monitored.

Some of the monitoring elements that Oregon Fish & Wildlife recommends appear to go beyond what is needed to monitor the effectiveness of resource measures that would be implemented under a new license. For example, the condition factor of trout collected during population assessments in the J.C. Boyle peaking reach would provide a good indication of fish growth without the need for conducting additional bioenergetics modeling, and there is no reason to believe that the project or any proposed measures would have any effect on the sex ratios of fish populations. In addition, spawner surveys conducted in the J.C. Boyle bypassed reach would demonstrate whether trout are able to access suitable spawning habitat without the need to conduct telemetry studies.

We conclude that the intent of the Forest Service recommendation to model and monitor integrated project effects would be encompassed by the implementation of several other measures. We describe these measures under sections 3.3.1, *Geology and Soils*, 3.3.2.2.2, *Water Quality*, and 3.3.3.2.6, *Iron Gate Hatchery Operations*; and in the integrated fish passage and disease management program that we evaluate in section 3.3.3.2.5, *Anadromous Fish Restoration*. The integrated fish passage and disease management program would include radio-telemetry studies to assess the movement rates and survival of anadromous fish passing through fishways, over spillways, through reservoirs, transported for different distances, and released at different locations.

We agree with NMFS and FWS that it would be beneficial for PacifiCorp to develop and implement an anadromous fish monitoring plan that would include recording and reporting the number, species, mark information, and the migration timing of any fish that are collected at fish ladders located at Iron Gate dam and at Iron Gate Hatchery, and of any fish that are collected for transport at these and any other fish collection facilities that are installed in the future. Information on water quality conditions and survival rates during transport and water quality conditions at the collection and release point also would assist with modifying procedures to maximize the survival rates of any transported fish. It also would be beneficial for PacifiCorp to mark any outmigrating juvenile anadromous fish that are transported and released downstream of Iron Gate dam, most likely using coded wire or PIT tags, so that the origin of adult fish that return to Iron Gate dam can be determined. If passage of anadromous fish is restored to any mainstem reaches within the project, it would be beneficial to monitor the timing and location of anadromous fish spawning activity in mainstem reaches and tributaries to determine whether fish survive to spawn and whether the available spawning habitat is sufficient to support restored populations of anadromous fish. This monitoring effort would help to determine the need for any measures to improve spawning habitat in project reaches that are used for spawning. Spawner surveys conducted during the steelhead spawning season also could provide incidental information on the density of rainbow trout redds, which could assist with tracking population responses to changes in project operations. We do not concur that it is the responsibility of PacifiCorp to monitor resident fish populations or juvenile anadromous fish production in tributary streams. If passage of anadromous fish to and from tributary streams is restored without latent adverse effects such as delayed mortality, this addresses the principal project effect on fish populations in that tributary. Therefore, we conclude that it is not PacifiCorp's responsibility to monitor the condition or productivity of these tributary habitats.

Responses to Monitoring

Oregon Fish & Wildlife also recommends that if, at any time, unanticipated circumstances or emergency situations arise in which non-ESA-listed fish or wildlife are being killed, harmed, or endangered by any of the project facilities or project operation, PacifiCorp should immediately take appropriate action to prevent further loss in a manner that does not pose a risk to human life and property. Within 48 hours of an event, PacifiCorp would notify Oregon Fish & Wildlife, NMFS, FWS, the Bureau of Land Management, Cal Fish & Game, the California State Water Resources Control Board, Oregon Environmental Quality, and the Oregon Water Resources Department, as appropriate, and comply with any restorative measures required by the resource agencies to the extent such measures do not conflict with the conditions of the license. PacifiCorp would be required to notify the Commission as soon as possible, but no later than 10 days after each event, and inform the Commission as to the nature of the event and of the restorative measures taken.

The Bureau of Land Management specifies that PacifiCorp develop an adaptive management plan in consultation with the Bureau that is designed to monitor how implementation of the "river corridor management condition" is effective in improving fish habitat quantity and quality for resident, migratory, and anadromous fish. Monitoring results and an evaluation of the results would be reported annually to the Bureau of Land Management, including PacifiCorp's conclusions about spawning, holding, feeding, juvenile rearing, riparian, and migratory habitat; and the adequacy of flows for providing migration, rearing, and spawning habitat for native aquatic species; moving spawning gravel; achieving riparian habitat objectives; supporting power generation; and providing recreational opportunities.

Our Analysis

It is reasonable to expect that in response to any type of environmental monitoring, if the need for corrective actions or opportunities for environmental enhancements becomes apparent, recommendations based on the monitoring results would be specified in any monitoring report submitted to the Commission for approval. We consider it most appropriate to include measures that would protect fish and wildlife

from identifiable sources of harm as specific conditions of a new license. However, in some instances, unanticipated project-related effects may result in unexpected mortality or injury to fish and wildlife. We conclude that establishing notification procedures to alert the management agencies of project-related fish or wildlife problems and to develop appropriate measures to minimize adverse effects, as Oregon Fish & Wildlife recommends, is both reasonable and appropriate.

As previously discussed, some habitat-related measures that the Bureau of Land Management specifies would constitute a substantial change from current operations, and would warrant monitoring to determine their effects and evaluating whether additional alteration of project operations may be warranted. However, because we do not support adopting several of the measures specified by the Bureau, we do not see a benefit in requiring PacifiCorp to monitor implementation of the Bureau's specified river corridor management condition. We conclude that alternative monitoring approaches would be equally effective in providing a basis for reaching adaptive management decisions.

3.3.3.3 Cumulative Effects

In this section we address cumulative effects on Chinook salmon, steelhead, rainbow trout, and Pacific lamprey. We address cumulative effects on coho salmon, shortnose suckers, and Lost River suckers in section 3.3.5.3.

3.3.3.3.1 Chinook Salmon

The settlement and development of the Klamath River Basin has caused substantial adverse cumulative effects on the habitat and population size of spring and fall Chinook salmon. Dams for impounding water for mining and farming operations were first built in the 1850s, and water uses associated with mining activities caused substantial increases in turbidity, siltation, and altering stream morphology. Starting around 1912, construction and operation of facilities associated with Reclamation's Klamath Irrigation Project resulted in extensive draining of wetlands, increased agricultural diversions, increased nutrient loading, and reduced dissolved oxygen levels. In the 1920s, the water resources in the Shasta and Scott rivers were developed to support irrigated agriculture, and the construction of Dwinnell dam blocked access for Chinook salmon to the southern headwaters. Agricultural diversions in these tributaries and in the tributaries to Upper Klamath Lake have reduced flows, increased water temperatures, and increased nutrient inputs. Also, as we discuss in section 3.3.2, *Water Resources*, extensive timber harvesting and conversion of land for resource extraction purposes (e.g., mining for gravel, gold, and other materials) throughout the watershed results in increased sediment and nutrient loads to the Klamath River, adversely affecting the rearing, migration, and spawning habitat of fall Chinook salmon.

Periodic changes in Pacific currents, winds, and upwelling regimes have substantial effects on the primary and secondary productivity of the northeast Pacific Ocean (Brown et al., 1994; Mantua et al., 1997). These oceanic events, described as El Niño/Southern Oscillation (ENSO) and Pacific decadal oscillation (PDO) are associated with declines and increases in ocean survival and decreases and increases in size of coho and Chinook salmon (Johnson, 1988; Spence et al., 1996; Tschaplinski, 1999; Cole, 2000; Ryding and Skalski, 1999; and Koslow et al., 2002). ENSO events are of relatively short duration (6-18 months) with their primary influence in the tropics and secondary expression in the North Pacific/North American sector. In contrast, PDO events are most visible in the North Pacific and typically cycle over periods of about 50 years; within a PDO cycle there may be short-lived reversals of conditions (Mantua, 2003). Substantial changes in ocean survival associated with these events can make it difficult to isolate and determine the effects of both long- and short-term changes in the condition of freshwater spawning and rearing habitats, and of conditions in the migration corridor downstream of Iron Gate dam.

Poor water quality in Keno reservoir related to nutrient inputs can largely be attributed to creating conditions that would block upstream or downstream passage of Chinook salmon during late spring and

much of the summer. This seasonal water quality migration barrier is the primary reason that NMFS and Interior included collection facilities for adult salmon at Keno dam and smolts at Link River dam. It would be unlikely that migrating salmon would be able to successfully pass through Keno reservoir under current late spring and summer water quality conditions. As such, the irrigation project has contributed to the blockage of suitable Chinook salmon habitat by creating a water quality migration barrier that is likely exacerbated by the presence of Keno dam. Diversion of up to 80 percent of the flow from the Trinity basin to support agriculture in the Sacramento River Basin started in 1964 with the completion of Trinity and Lewiston dams. Timber harvest practices and grazing have also contributed to erosion, damage to riparian habitat, and increased water temperatures. Overfishing and competition with Chinook salmon produced at Iron Gate Hatchery also has adversely affected wild runs of Chinook salmon in the basin.

Construction of Copco No. 1 dam in 1918 blocked Chinook salmon from accessing more than 350 miles of habitat upstream of Upper Klamath Lake and 55.7 miles of mainstem habitat between Copco No. 1 dam and Upper Klamath Lake. Construction of Iron Gate dam in 1964 blocked access to another 8.2 miles of mainstem habitat and tributaries including Fall and Jenny creeks.

The Klamath Hydroelectric Project contributes to adverse cumulative effects on Chinook salmon by blocking access to habitats upstream from Iron Gate dam. The project contributes to the cumulative effects associated with nutrient inputs from upstream, non-project sources by providing seasonal increases in nutrients, and diurnal fluctuations in DO levels and pH downstream of Iron Gate dam associated with plankton blooms in the project reservoirs. Several project effects act in a cumulative manner to contribute to disease losses downstream of Iron Gate dam, including an increase in the density of salmon spawning below the dam, increased habitat for disease pathogens and their alternate hosts due to seasonally increased nutrient inputs and armoring of the stream bed, which provides a stable substrate for the growth of attached algae, and increased disease susceptibility caused by stressful water quality conditions. The increased prevalence of disease pathogens attributable to the project, combined with nutrient enrichment and reduced streamflows caused by the upstream Klamath Irrigation Project, likely contribute to losses of juvenile Chinook salmon outmigrating through tributaries downstream of Iron Gate dam, affecting populations in the Shasta, Scott, Salmon, and Trinity rivers.

Implementing fish passage through the project via installation of volitional passage facilities, implementation of a trap and haul program, or by dam removal would help to reduce adverse effects associated with blocked access to historic habitats, which would alleviate the crowded spawning conditions downstream of Iron Gate dam. Implementing measures to reduce nutrient inputs, decrease water temperatures or increase DO levels also would help to reduce cumulative effects on Chinook salmon. Cumulative effects associated with disease losses could be reduced by implementing effective disease management measures, which would be evaluated and developed in the integrated fish passage and disease management program that we include in the Staff Alternative. Removal of one or more dams, especially Iron Gate and Copco No. 1 dams, is likely to alleviate conditions that are conducive to the spread of fish disease by reducing the crowding of spawners downstream of Iron Gate dam, reducing the abundance of the alternative host of two key fish pathogens by reducing the abundance of attached algae, and alleviating water quality conditions that cause fish stress and increase susceptibility to disease. Removal of Iron Gate dam, however, would eliminate the cool water supply to Iron Gate Hatchery, and stopping hatchery operations would likely necessitate fishery restrictions for at least several years while anadromous fish stocks become established in newly accessible habitat. It is also clear, however, that the blockage of Chinook salmon from historical upstream habitat and disease problems in the lower Klamath River are currently not solely the result of the construction of project dams. Therefore, a cooperative approach that involves PacifiCorp and Reclamation (at a minimum) would be most effective in protecting and restoring anadromous fish to habitat within the project area, upstream of Upper Klamath Lake, and downstream of Iron Gate dam.

3.3.3.3.2 Steelhead

Steelhead are influenced by many of the same cumulative effects as Chinook salmon that are attributable to historic mining practices, agricultural development, forest practices, grazing, and hydroelectric development. The pathways in which the Klamath Hydroelectric Project contributes to these cumulative adverse effects are also similar to those that we describe for Chinook salmon. Although disease losses of steelhead in the migratory corridor have not been monitored extensively, steep declines in the returns of steelhead to Iron Gate Hatchery since 1992 suggest that adverse conditions may exist in the migratory corridor for this species as well.

Implementing fish passage either through installation of volitional passage facilities, implementation of a trap and haul fish passage program, or by dam removal would help to reduce adverse effects associated with lost access to upstream spawning habitats. Implementing measures to reduce nutrient inputs, reduce water temperatures, or increase DO levels also could reduce cumulative effects on steelhead. Implementing an effective disease management program may reduce the potential losses of steelhead from fish diseases. The Klamath Hydroelectric Project plays a role in the cumulative adverse affects on steelhead, along with other entities. Restoration of steelhead to historical habitat and restoration of currently accessible habitat downstream of Iron Gate should be a cooperative effort to maximize the opportunities for success.

3.3.3.3.3 Rainbow Trout

Resident rainbow trout have been affected by many of the same cumulative effects as steelhead associated with historic mining practices, agricultural development, forest practices, grazing, and hydroelectric development. Construction of numerous tributary dams and agricultural development of the basin has reduced habitat connectivity, reduced recruitment of spawning gravel to historic rainbow trout habitats, altered river flows, and adversely affected water quality by increasing water temperatures and nutrient loads, reducing DO, and introducing pesticides.

Implementing fish passage either through installation of volitional passage facilities, implementation of a trap and haul fish passage program, or by dam removal would help to improve connectivity among rainbow trout populations in the project area and may increase the productivity of some tributaries by restoring the supply of marine-derived nutrients provided by the carcasses, eggs, and young of anadromous fish. However, increasing the supply of nutrients could adversely affect water quality conditions in the mainstem Klamath River and in project reservoirs, which currently are subject to elevated nutrient loads contributed from agricultural sources in the upper basin. Sediment augmentation in the J.C. Boyle bypassed reach, as PacifiCorp proposes, would help to alleviate the reduced recruitment of spawning gravel. Eliminating agricultural diversions on Negro and Shovel creeks, also proposed by PacifiCorp, would also help to improve trout recruitment from that tributary, compensating for lost access and diminished quality of mainstem spawning habitats due to trapping of gravel in project reservoirs.

3.3.3.3.4 Pacific Lamprey

The overall distribution and abundance of Pacific lamprey on the Pacific Coast has been severely reduced due to effects associated with hydropower development. The construction of numerous mainstem and tributary dams has reduced the amount of habitat that is accessible for freshwater spawning and rearing of this species over most of its range. Although a substantial amount of habitat suitable for lampreys remains accessible in the Klamath River Basin, accounts given by tribal elders indicate that the number of lampreys in the river has declined precipitously from historic levels (Larson and Belchik, 1998). Because the species is not known to exhibit a high degree of fidelity to its native stream, we conclude that the decline in the number of Pacific lamprey returning to the Klamath River may be an outcome of the overall coast-wide decline of the species.

The Klamath Hydroelectric Project contributes to adverse cumulative effects on Pacific lamprey by blocking access to potential habitat upstream of Iron Gate dam, assuming that they historically migrated upstream of Iron Gate dam. Implementation of the NMFS/Interior fishway prescription or a trap and haul fish passage program may provide little benefit to the species for two reasons. First, effective technology for providing downstream passage for outmigrating Pacific lamprey at hydroelectric projects has not been developed, and it is likely that there would be substantial losses to predation during migration through project reservoirs. Second, adult lamprey do not appear to be effectively attracted to the existing fish ladders associated with Iron Gate Hatchery.

3.3.3.4 Unavoidable Adverse Effects

If the project is relicensed without removal of Iron Gate or Copco No. 1 dams, the project would likely continue to adversely affect water quality conditions downstream of Iron Gate dam, which adversely affects Chinook salmon during their outmigration through the lower Klamath River. A project-specific water quality management plan would identify measures that could be implemented to minimize project-related water quality degradation of salmon and steelhead habitat. Although some entrainment mortality of rainbow trout would continue, the level of entrainment that has occurred in the past has not caused substantial adverse effects on the trout fishery in the Keno or J.C. Boyle bypassed and peaking reaches, which are among the best trout fisheries in the region.

3.3.4 Terrestrial Resources

3.3.4.1 Affected Environment

3.3.4.1.1 Botanical Resources

The Klamath Hydroelectric Project is located near the confluence of the Siskiyou, Klamath, and Cascade mountain ranges and within several different eco-regions or physiographic provinces, resulting in a diverse mix of flora and fauna. In Oregon, the Oregon Diversity Plan refers to these eco-regions as the East Slope Cascades and the West Slope Cascades. In California, the project is within the Southern Cascades and the Modoc Plateau physiographic provinces and is also within the Cascade-North Sierra floristic region of the California floristic province. The Upper Klamath River forms a corridor between the Great Basin and California floristic provinces, creating a transition zone. Within Oregon, the area is generally within the interior valley, ponderosa pine, and mixed conifer vegetation zones. The Klamath River Canyon (from the J.C. Boyle development to the California-Oregon state line) has the greatest botanical diversity of any section of the river.

The area east of J.C. Boyle dam generally includes vegetation typical of the East Slope Cascades physiographic province. In the Klamath River Basin, non-forested areas in the valley are generally sagebrush steppe vegetation, wetlands, or are cultivated. From J.C. Boyle dam to the eastern end of Copco reservoir, the Klamath River cuts through several vegetation zones as it bisects the Cascade Range, forming a steep canyon. Montane vegetation typical of the Cascades is mixed with high desert and interior valley plant communities. The area downstream of the canyon is composed of vegetation similar to that found in the interior valley of Oregon, with oak and grasslands dominating.

PacifiCorp characterizes the Klamath River Canyon as a mosaic of pine, oak, juniper, and mixed conifer forest communities, with ponderosa pine and Oregon white oak (*Quercus garrayana*) being the dominant tree species. Limited areas of oak savannahs also occur. Narrow riparian habitats dominated by oak, birch (*Betulua occidentalis*), and white alder (*Alnus rhombifolia*) occur along the river and tributaries. Overall oak production in the Klamath River Canyon was reported to be less than 20 percent of the potential productivity, although the trees within the canyon tend to produce more acorns while the poor-production trees are located outside of the canyon.

Cover Types and Unique Habitats

As table 3-79 shows, PacifiCorp identified and mapped 12 upland cover types, 8 riparian and wetland habitats, 4 aquatic habitats, 2 barren habitats, and 5 kinds of agricultural or developed lands in the project vicinity.[97] Upland tree-dominated cover types are most abundant in all locations except at the Keno reservoir and along the Klamath River from the Iron Gate development to the Shasta River. From Iron Gate development to the Shasta River, riparian cover types occupy approximately 25 percent of the area. Developed and agricultural lands dominate the area near Keno reservoir (48 percent). Upland shrub cover types occupy a low of 7 percent of the area at Iron Gate reservoir to a high of 21 percent near the Copco No. 2 bypassed reach. Upland herbaceous cover types are common along the Klamath River between the Iron Gate development and the Shasta River and at the Iron Gate and Copco reservoirs, occupying between 16 and 26 percent of these areas. Agricultural habitat (excluding general grazing allotment areas) occupies more than 20 percent of the area along Link River, at Keno reservoir, and along the Klamath River from Iron Gate development to the Shasta River, but represents less than 2 percent in the rest of the project vicinity.

Table 3-79. Cover types and habitats mapped in the vicinity of the Klamath Hydroelectric Project. (Source: PacifiCorp, 2004a)

Cover Type/Habitat	Acres	Description, Dominant Species, and Location
All upland tree habitats	28,317	More than 10 percent total cover by tree species; common from Keno reach to Iron Gate reservoir.
Montane hardwood oak	5,071	Moderately open tree canopy, moderately dense shrub layer, moderately dense herbaceous layer. Yellow starthistle and medusahead occur in about 25 percent of stands in the project vicinity. Most abundant around Iron Gate reservoir, Copco reservoir, and along J.C. Boyle peaking reach.
Montane hardwood oak-conifer	8,638	Dense tree cover, sparse shrub layer, moderately open herbaceous layer. Most abundant along the J.C. Boyle peaking and bypassed reaches, at Copco reservoir, at Fall Creek, and along Copco No. 2 bypassed reach.
Montane hardwood oak-juniper	8,968	Open tree layer, sparse shrub layer, dense herbaceous layer. Yellow starthistle and medusahead occur in 45 percent of stands, primarily around Iron Gate and Copco reservoirs and along Copco No. 2 bypassed reach. Most abundant cover type in the project vicinity.
Ponderosa pine	3,473	Moderate canopy cover, relatively sparse shrub cover, moderately open herbaceous layer. Most abundant along Keno reach and at J.C. Boyle reservoir.
Juniper	1,268	Open canopy, shrub layer varies from sparse to dense, herbaceous layer ranges from sparse to dense. Most abundant along Link River and along J.C. Boyle peaking reach.
Mixed conifer	834	Dense tree cover is often two-layered, open shrub layer, moderately sparse herbaceous layer. Approximately 70 percent of stands are along J.C. Boyle bypassed reach.

[97]The project vicinity includes the Klamath River from Link River dam to the Shasta River, the area within 0.25 mile of all project facilities, reservoirs, and river reaches; the land in the Klamath River Canyon; and all PacifiCorp land in the area, but outside of the 0.25-mile buffer.

Cover Type/Habitat	Acres	Description, Dominant Species, and Location
Lodgepole pine	64	Lodgepole pine stands occur along J.C. Boyle bypassed reach and at J.C. Boyle reservoir as a result of replanting following timber harvest. Sparse tree layer, sparse shrub layer, dense herbaceous layer.
All upland shrub habitats	5,042	More than 10 percent total cover by shrub species and less than 10 percent total cover by tree species
Mixed chaparral	4,396	Requires occurrence of two or more shrub species, each covering 5 percent or more of the area. Very few trees, moderate shrub layer, herbaceous layer varies from sparse to dense. Approximately 60 percent occurs along J.C. Boyle bypassed reach and around Copco reservoir.
Sagebrush	108	Moderately dense shrub layer, sparse herbaceous layer. This limited habitat type occurs near Keno and J.C. Boyle reservoirs.
Rabbitbrush	538	Gray rabbitbrush is the dominant shrub species in most areas and Sierra plum is the only other shrub species present within this cover type. Moderately dense herbaceous layer. Applegate's milk-vetch, a federally endangered plant species, grows in a seasonally moist site with rabbitbrush and saltgrass along Keno reservoir. Occurs at Keno reservoir and along Keno reach.
All upland herbaceous habitats	4,841	More than 2 percent total cover by herbaceous species and less than 10 percent total cover of tree and/or shrub species.
Annual grassland	4,474	Total shrub cover is less than 1 percent. Nine of the 11 most frequent herbaceous species are introduced species; two of them are the exotic/invasive species medusahead and yellow starthistle. Cheatgrass is relatively more abundant in annual grasslands along Keno reservoir and along J.C. Boyle bypassed reach. Medusahead, hairy brome, and yellow starthistle dominate grasslands downriver of J.C. Boyle peaking reach. More than 88 percent of the annual grasslands occur along J.C. Boyle peaking reach and around Copco and Iron Gate reservoirs.
Perennial grassland	366	Sparse shrub cover includes a wide variety of species. A total of 31 graminoid species occurs; 5 introduced annuals, 11 introduced perennials, 2 native annuals, 10 native perennials, 1 native rush, and 2 native sedges. More than 87 percent occurs around J.C. Boyle reservoir and in the J.C. Boyle peaking and bypassed reaches.
All wetlands and riparian plant communities	2,836	
Palustrine emergent wetland	1,796	Dense herbaceous layer, often with a weedy zone immediately upslope of the bulrush zone. Short-podded thelypody, a special status species, occurs in this habitat type at Keno reservoir. More than 88 percent occurs adjacent to Keno reservoir, where wetlands associated with the Klamath Wildlife Area and the undiked wetlands southwest of the Klamath Wildlife Area are located. The largest single emergent wetland associated with the project covers more than 63 acres and is near Sportsman's Park at J.C. Boyle reservoir.

Cover Type/Habitat	Acres	Description, Dominant Species, and Location
Palustrine scrub-shrub wetland	31	Open canopy with moderate shrub layer. Coyote willow (also known as narrowleaf willow) and arroyo willow are the primary hydrophilic shrubs. Arroyo willow is more abundant upriver and upslope. The only shrub layer species in the Link River wetland is arroyo willow; this species was most frequent at Keno reservoir, J.C. Boyle reservoir, and Fall Creek. Species dominating the Spencer Creek wetland include arroyo willow and coyote willow. Arroyo willow also occurred in the Fall Creek reach. Coyote willow is the dominant shrub layer species in 75 percent of the wetlands from J.C. Boyle reservoir to Iron Gate reservoir. More than 80 percent occurs adjacent to J.C. Boyle, Copco, and Iron Gate reservoirs.
Palustrine forested wetland	119	Dense tree cover includes the primarily hydrophilic tree species coyote willow and shining willow; weeping willow is the dominant tree layer species in one of the Keno reservoir wetlands. The two Keno reservoir wetlands have no shrub layer. Brown dogwood and arroyo willow are the only species in the open shrub layer of the two wetlands along Copco No. 2 bypassed reach. Wetlands at Copco and Iron Gate reservoirs had an open shrub layer with coyote willow. More than 80 percent occurs adjacent to Copco and Iron Gate reservoirs.
Palustrine aquatic bed	293	Occurs in all project reservoirs and slow moving sections of the Klamath River. Dominant species are pondweeds and coontail.
Riparian grassland	60	Dense herbaceous cover. Reed canarygrass is relatively common along Link River, along Keno reach, and along J.C. Boyle peaking reach.
Riparian shrub	121	Coyote willow, arroyo willow, and Oregon ash saplings are the primary hydrophilic shrubs. Dense herbaceous cover is dominated by reed canarygrass along Link River, Keno reach, J.C. Boyle bypassed reach, and J.C. Boyle peaking reach. J.C. Boyle peaking reach and Klamath River from Iron Gate development to Shasta River are the locations with the most riparian shrub habitat.
Riparian deciduous	365	Moderate canopy cover includes coyote willow. Moderate shrub and herb layers. Occurs primarily along J.C. Boyle peaking reach and along the Klamath River from Iron Gate development to Shasta River.
Riparian mixed deciduous-coniferous	52	A total of 8 tree, 12 shrub, and 49 herbaceous plant species were documented in this habitat. Dense tree layer, moderate shrub layer, open herbaceous layer. A taller herb layer with reed canarygrass and devil's beggarstick is often present along the river. 37.8 acres are mapped at Fall Creek, 12.0 acres along J.C. Boyle peaking reach, and 1.9 acres around Copco reservoir.
Riverine and lacustrine habitats	5,077	The reservoirs represent 4,333 acres of lacustrine habitat in the project vicinity. Riverine unconsolidated bottom, which includes the semipermanently flooded flowing water of the Klamath River, totaled 726 acres. Riverine and lacustrine unconsolidated shoreline or gravel bar habitats cover 17.2 acres. Several reservoirs and river reaches have pockets of submerged aquatic vegetation.

Cover Type/Habitat	Acres	Description, Dominant Species, and Location
All barren habitats	926	Less than 2 percent total cover by herbaceous, desert, or non-wildland species; less than 10 percent cover by tree or shrub species.
Rock talus	559	Most rock talus habitats are barren with small patches of vegetation where the talus is thin or at the margins of the talus patch. 2 tree, 7 shrub, and 23 herbaceous plant species provided sparse cover in rock talus habitats. Particularly abundant along J.C. Boyle peaking and bypassed reaches.
Exposed rock	367	A wide variety of species occurs in the sparse shrub and moderate herb layers. Most abundant along J.C. Boyle peaking and bypassed reaches and Copco No. 2 bypassed reach; does not occur at Link River or Keno reservoir.
Developed and disturbed habitats	5,830	More than 2 percent total vegetation cover is non-wildland vegetation. Includes three developed vegetation types: residential, recreational development, and industrial, where vegetation includes plants grown for landscaping. Also includes agricultural types such as pasture and irrigated hayfields, where vegetation includes plants grown for food and/or fiber. Pastures and irrigated hayfields are distributed over 3,682 acres. More than 85 percent of the pasture/irrigated hayfields occur around Keno reservoir. J.C. Boyle peaking reach and the area along the Klamath River from Iron Gate development to Shasta River also have a substantial amount of pasture/irrigated hayfields.

The relative and absolute cover of wetlands is greatest along Keno reservoir with nearly 20 percent or 1,866 acres of wetland habitat that was mapped by PacifiCorp during the terrestrial resources studies. The relative cover of wetland cover types in the rest of the project vicinity ranges from 0.2 percent or 5.1 acres in the Keno reach to 5.5 percent or 105 acres at J.C. Boyle reservoir.

PacifiCorp identified three primary vegetative habitats of special concern that occur in the project vicinity based on its review and understanding of the Clean Water Act (33 U.S.C. §1341), the Northwest Forest Plan (Forest Service and Bureau of Land Management, 1994), and the Klamath Falls Resource Area Resource Management Plan (Bureau of Land Management, 1995). These habitats are riparian and wetland habitats, late-successional conifer forest, and snag and coarse wood rich habitats.

Riparian and Wetland Habitats

Wetlands provide habitat for many plant and wildlife species, collect and hold water, buffer the effects of floods, and conserve moisture for drier seasons. Riparian areas provide critical diversity and stability in forested ecosystems, including (1) multiple vegetation layers with a variety of nesting sites, cover areas, and food sources for wildlife; (2) vegetation that absorbs nutrients and sediment; (3) vegetation roots that stabilize streambanks, lake shores, and adjacent slopes; and (4) vegetation that shades streams and maintains low water temperatures. Riparian areas support more wildlife species than adjacent uplands, particularly in arid environments, and are particularly important for breeding birds.

Under current conditions, between 19 and 30 percent of the shorelines along J.C. Boyle, Copco, and Iron Gate reservoirs are bordered by riparian and/or wetland habitat. Currently, wetland and riparian vegetation along reservoirs is limited mostly to small patches in protected locations and near inlets/tributaries. There are, however, several large wetland and riparian habitats associated with J.C. Boyle reservoir and tributaries and seeps near the other project reservoirs.

Link River. The riparian vegetation at Link River is influenced by river hydrology and by seepage from the West Side and East Side canals and penstocks. Seepage, especially from the West Side canal, has created many perched wetland habitats well away from the hydrological influence of normal river flows in the reach. The riparian vegetation at Link River is unique compared to other project reaches because of the presence and abundance of introduced woody species. Apple, plum, and elm are commonly the dominant species in the tree layer. Reed canarygrass is abundant in close proximity to the active channel and in seepage areas. Five vegetation types are found in the riparian/wetland community along the Link River.

Keno Reservoir. The wetland vegetation at Keno reservoir is more diverse than at any other project reservoir, probably because of the wide variety of land uses that have modified habitats around the reservoir. The most abundant wetland vegetation types are dominated by hardstem bulrush and broad-fruited bur-reed. Ten vegetation types are found in the riparian/wetland community at the Keno reservoir; hardstem bulrush/stinging nettle/cattail is the most abundant. Hardstem bulrush/broad fruited bur-reed/duckweed/knotweed is one of the most abundant vegetation types at the edge of the reservoir pool. The coyote willow vegetation type, which is dominated by coyote willow in the shrub layer, is not common at the Keno reservoir, but occurs in dense, small stands in low-lying pastures protected by levees. Two coyote willow stands are located at the downstream end of the Keno reservoir. One of these stands was recently disturbed, most likely by grazing, and has young coyote willow that appear to be increasing in abundance. The other stand has not been disturbed for many years and has much older coyote willow and arroyo willow at the upper end of a long, low-gradient slope.

Keno Reach. The most frequently occurring of the nine vegetation types PacifiCorp documented in the riparian plant species growing in the Keno reach are reed canarygrass, hardstem bulrush, and river bulrush; these species are well-suited to coarse substrates that are frequently inundated by fast-moving water. The reed canarygrass vegetation type was found on mid-channel islands and at the water's edge among large boulders; this is the most abundant riparian vegetation type in the Keno reach. The hardstem bulrush/devil's beggarstick and hardstem bulrush vegetation types also occur on mid-channel islands and at the water's edge, but in more open water than the reed canarygrass vegetation type. Other riparian plant species were scarce by comparison and were restricted primarily to narrow benches or terraces. PacifiCorp observed some large shining willow trees on a narrow, low-gradient terrace among dense stands of reed canarygrass. All of the willow trees are in a state of decay and have large horizontal branches broken because of rot or chewing by beavers. Willow reproduction does not currently occur in this reach.

J.C. Boyle Reservoir. Approximately 30 percent of the J.C. Boyle reservoir shoreline currently is bordered by riparian and wetland vegetation. Vegetation in the J.C. Boyle reservoir riparian/wetland zone is generally restricted to herbaceous types, but some woody riparian vegetation occurs in palustrine scrub-shrub wetlands in Spencer Creek, a major tributary to the reservoir. Pre-project aerial photography indicates that only a narrow band of riparian/wetland vegetation with few trees or shrubs bordered the Klamath River in this area and occurred in approximately the same proportion of the river shoreline as currently exists along the reservoir shoreline. The limited historical occurrence of willow in the area may explain why there are generally few willows along the J.C. Boyle reservoir today.

The current wetland/riparian zone at the J.C. Boyle reservoir is often perched on a low bench or low gradient slope above the current full pool level and averages between 68 and 204 feet wide. The riparian/wetland community at this reservoir is composed of six vegetation types. The most abundant vegetation type at the J.C. Boyle reservoir is the sedge/Baltic rush/bentgrass/Kentucky bluegrass vegetation type. Reed canarygrass is relatively uncommon at the J.C. Boyle reservoir and only occurs at elevations that are inundated 14 to 93 percent of the growing season.

J.C. Boyle Bypassed and Peaking Reaches. The riparian/wetland community in the J.C. Boyle bypassed and peaking reaches is composed of 11 vegetation types. Oregon oak/western

serviceberry/snowberry occurs at the upper end of the elevation gradient supporting riparian vegetation and is one of the most abundant vegetation types abutting the river. Oregon ash/colonial bentgrass/woolly sedge includes arroyo willow in the shrub layer; Oregon ash/Himalayan blackberry occurs on the right bank downstream of Beswick Ranch and includes coyote willow in the tree layer; coyote willow/reed canarygrass/colonial bentgrass, is most abundant on low-gradient terraces, although small clumps of coyote willow were observed on banks with a steeper gradient.

Reed canarygrass is the most abundant species in the J.C. Boyle peaking reach varial zone, which is that portion of the channel's margin associated with project peaking flow fluctuations between 350 and 3,000 cfs (PacifiCorp, 2005d). Reed canarygrass may have a distinct competitive advantage in the varial zone because of its ability to better use abundant nutrients and withstand frequently fluctuating peaking flows. It has been shown to be highly adaptable under a wide range of growing conditions and appears to respond favorably to various inundation patterns and to nutrient supply (PacifiCorp, 2005d). Reed canarygrass seeds germinate best immediately following maturation; however, some seed remains viable throughout the winter and following summer giving this species a competitive advantage.

Between 65 and 100 percent of the remaining peaking reach riparian/wetland vegetation types occur above the varial zone. Very little dense reed canarygrass occurs above the varial zone. The most evenly distributed vegetation types across the upper boundary of the varial zone include coyote willow/reed canarygrass/colonial bentgrass, perennial ryegrass, and Oregon ash/colonial bentgrass/woolly sedge. The three vegetation types occurring in high numbers within or below the varial zone include coyote willow/reed canarygrass/bentgrass, reed canarygrass, and hardstem bulrush/reed canarygrass.

In the J.C. Boyle peaking reach, young willows grow at several locations on the higher elevation portions of mid-channel islands; Douglas' spiraea was observed growing on larger terraces. There was no strong association between coyote willow abundance and position along the inundation/elevation gradient within the varial zone of the peaking reach (willow generally occurs at elevations above the varial zone). Coyote willow seeds disperse in May and June and are viable only for about 1 week after dispersal and require bare, alluvial surfaces in close proximity to the water table for germination. Willow seeds are also capable of photosynthesis and require light to successfully germinate. Coyote willow is intolerant of shade in all stages of growth. Reed canarygrass may prohibit willow germination by shading, and daily peaking may inhibit willow germination by flooding seed and seedlings before they can develop. However, coyote willow is a colonizing species and may not colonize new areas from seed, but instead may invade new areas by vegetative suckering and possibly by root fragments. Coyote willow colonies along the peaking reach often had large, decaying stems surrounded by suckers of various ages growing up through reed canarygrass. Coyote willow sprouts were observed in the coyote willow/reed canarygrass/colonial bentgrass, reed canarygrass, and hardstem bulrush/reed canarygrass vegetation types.

The width of the riparian vegetation zone in many parts of the J.C. Boyle peaking reach is dictated by geomorphological constraints, especially in the steeper portions of the reach. The J.C. Boyle peaking reach tends to have narrow, often discontinuous bands of riparian vegetation along the river's margin. PacifiCorp's review of historic aerial photography indicates a general lack of disturbance of the general character and size of the riparian zone in the J.C. Boyle peaking reach over time. PacifiCorp attributes a variety of factors that probably contribute to the relative lack of disturbance, including coarse substrates that resist scouring during large flow events, the lack of finer particle sizes in the river required for sedimentation, streambanks stabilized by dense vegetation that also resist scouring, and possibly an attenuation of potentially scouring flood flows during major flood events as a result of upper basin diversions (PacifiCorp, 2005d).

Copco Reservoir. About 19 percent of Copco reservoir shoreline is bordered by four types of wetland and riparian habitat: starthistle/medusahead/hairy brome, coyote willow, hardstem bulrush/broad-fruited bur-reed/duckweed/knotweed, and hardstem bulrush/stinging nettle/cattail. This lack of substantial riparian and wetland habitat is largely the result of the generally steep slopes along the

shoreline. The bank slope averages about 19 percent, compared to 3 percent at the J.C. Boyle reservoir. Only along low-gradient shorelines, especially near inlets, is the topography suitable for riparian and wetland vegetation development. Residential development at the upper portion of the reservoir reduces shoreline available for native vegetation. Currently, most of the wetland and riparian habitat is herbaceous, although in some areas coyote willow is abundant. Shining willow and arroyo willow are not common and the absence of bare substrates at elevations suitable for willow seed germination may be the most important factor limiting the distribution of willow. Coyote willow establishment occurs on bare substrates with good light. Around Copco reservoir, as at the other reservoirs, there is a high incidence of weedy species although reed canarygrass is uncommon and only occurs in locations with 25 to 67 percent inundation.

Copco No. 2 Bypassed Reach. The riparian vegetation in the Copco No. 2 bypassed reach is influenced by river flows that are low compared to pre-project flows. The lower water level has made more potential substrate available for establishment of riparian and wetland plants on previously inundated portions of the channel bed. An abundance of riparian vegetation has encroached, particularly in closer proximity to and at lower elevations in the active channel of the Copco No. 2 bypassed reach. Copco dam predates the first available aerial photographs for this reach (1955) by approximately 30 years, but encroachment was evident to PacifiCorp when comparing 1955 and 1994 aerial photos. Four vegetation types occur in the riparian/wetland community of the Copco No. 2 bypassed reach. A distinct separation of the vegetation types by elevation occurs along the Copco No. 2 bypassed reach despite the fact that seepage from the adjacent penstock intercepts the left bank in many places and creates many wetland habitats in the former active river channel. The riparian vegetation along the Copco No. 2 bypassed reach is unique because many large white alder dominate the tree canopy. The dense white alder canopy may contribute to the scarcity of the shade-intolerant coyote willow and reed canarygrass relative to other project reaches.

Fall Creek. The riparian vegetation at Fall Creek is influenced by a combination of Fall Creek flows and by seepage from the Fall Creek canal. Seepage from the canal has created wetland habitats between the canal and the left bank of Fall Creek that occur only because of canal seepage. In downstream portions of Fall Creek where the flow is not influenced by canal seepage, the gradient steepens and the riparian vegetation zone becomes narrow. The riparian vegetation at Fall Creek is unique compared to other project reaches due to the presence and abundance of conifers in the riparian zone and the absence of coyote willow. Four riparian/wetland vegetation types occur along Fall Creek: Oregon ash/western birch, Oregon ash/Douglas' spiraea, white alder, and ponderosa pine/Douglas fir/western serviceberry, which occurs in drier and more upland areas. The relatively long history of upstream diversion since 1903 (Spring Creek and Fall Creek canal) and seepage from the Fall Creek canal have created a riparian zone with both wetland and upland species growing in proximity to one another.

Iron Gate Reservoir. Currently, about 22 percent of the Iron Gate reservoir shoreline is bordered by riparian and wetland vegetation. The bank slope averages 23 percent, and the steep shorelines that border much of the reservoir are not conducive for extensive riparian and wetland development. Trampling and grazing by cattle along some sections of the reservoir shorelines likely contribute to the degraded nature of the riparian/wetland communities. Historically, the river in this area was bordered by narrow bands of riparian shrub and deciduous vegetation (approximately 68 percent of shoreline) with oak and grassland types interspersed. PacifiCorp classified five vegetation types in the riparian/wetland community at Iron Gate reservoir. There are many narrow patches of coyote willow along the sections of low-gradient shoreline, particularly in protected inlets, and along steeper shorelines where surrounding uplands have slumped or eroded into the water creating a shelf that provides the appropriate substrate and inundation pattern. Some of the youngest willow stands are located along the peninsula that is roughly due south of the Camp Creek campground. Reed canarygrass is not common, and only occurs in locations with inundation durations of 9 and 28 percent.

Klamath River from Iron Gate Dam to Shasta River. The riparian/wetland community in this reach includes 12 vegetation types; coyote willow occurs in almost all of the vegetation types in this reach, in the tree, shrub, and herbaceous layers. Coyote willow/Himalayan blackberry is the most abundant vegetation type in this reach. Coyote willow/poison hemlock occurs in slightly more hydric habitats and has many more young coyote willow sprouts in the herbaceous layer compared to other willow-dominated stands in this reach, as well as tree and shrub layers dominated by coyote willow.

The vegetation types in the Klamath River from the Iron Gate dam to the Shasta River fall into three groups that occupy three generally different elevation zones. Group 1 consists of vegetation types that typically grow in or just upgradient of the water surface: coyote willow/knotweed, rice cutgrass/hardstem bulrush, hardstem bulrush/duckweed, and curly pondweed. Group 2 consists of vegetation types that occupy bars and islands in the river channel and the lower floodplain elevations: coyote willow/Himalayan blackberry, coyote willow/poison hemlock, and Oregon ash/bentgrass/woolly sedge. Group 3 consists of vegetation types that occupy steep banks and higher floodplain elevations: Oregon oak/bentgrass/Kentucky bluegrass, medusahead/cheatgrass, Oregon oak/blue wildrye, and chicory/tall fescue.

Woody riparian vegetation is more abundant in the reach from the Iron Gate dam to the Shasta River than in any other project reach. However, the tree-dominated stands are typically much smaller in area than some of the Oregon ash-dominated stands along the J.C. Boyle peaking reach, white alder stands along the Copco No. 2 bypassed reach, and non-native, tree-dominated stands along Link River. Coyote willow is most abundant in this reach, especially downstream of Cottonwood Creek and immediately downstream of Iron Gate dam. Reed canarygrass is not common along the river downstream of Iron Gate dam for unknown reasons.

Late-Successional Conifer Forest

According to the Northwest Forest Plan (Forest Service and Bureau of Land Management, 1994), late-successional forests are those in which the biggest, oldest, and most dominant trees create a maturing canopy with shade-tolerant trees occupying and flourishing on the forest floor. Typically, late-successional forests include trees at least 80 years old. Late-successional forests provide important wildlife habitat for a large number of wildlife species. Forests on both the east and west sides of the Cascades tend to have more species associated with large trees that are typically associated with late-successional conifer forest and especially with multi-canopy stands. PacifiCorp determined that only 13 acres of forest in the Klamath Hydroelectric Project vicinity near the J.C. Boyle peaking reach included late-successional conifer forest with large-diameter (greater than 24 inches in diameter 4.5 feet above the forest floor) trees. However, there are also 8,435 acres of younger forest with small to moderately large diameter (11 to 24 inches) trees.

Snag and Coarse Wood Rich Habitat

Researchers have documented that snags (dead trees that are still standing or part of a dead tree from which the leaves and smaller branches have fallen) and down wood are important to wildlife. In Douglas-fir forests of southern Oregon, species richness of terrestrial vertebrates (i.e., small mammals, insectivores, and amphibians) increases with increasing volumes of coarse woody debris. The Klamath Falls Resource Area Resource Management Plan (Bureau of Land Management, 1995) calls for maintaining the number of snags needed to support at least 60 percent of the maximum biological potential of cavity-nesting species over time. Recent research indicates that greater numbers of snags are needed to provide for wildlife habitat needs and ecosystem function than was previously thought.

PacifiCorp grouped snag data collected during its cover type mapping into the size categories and decay classes used by six primary cavity-nesting species known to occur in the project vicinity in order to determine if the study area met the guidelines in the Klamath Falls Resource Area Resource Management

Plan (Bureau of Land Management, 1995). PacifiCorp determined that the Klamath Hydroelectric Project vicinity provides sufficient snags to meet at least 60 percent of the maximum population needs for six primary cavity-nesting species that occur there—downy woodpecker, hairy woodpecker, pileated woodpecker, acorn woodpecker, Lewis' woodpecker, and redbreasted sapsucker. Riparian deciduous, riparian mixed, and riparian shrub vegetation types all greatly exceed the density of snags needed to provide for 100 percent of the maximum biological potential for all species except acorn, pileated, and Lewis' woodpeckers, which require snags more than 17 or 25 inches in diameter 4.5 feet above the forest floor. However, the forested wetlands meet the 60 percent level for all species except the hairy woodpecker. Scrub-shrub wetlands provide adequate snags for all species except pileated woodpecker. Snags suitable for downy woodpeckers (more than 11 inches in diameter) occur primarily in riparian mixed deciduous-coniferous forest, and the density greatly exceeds the number needed to maintain downy woodpecker populations. The density of snags more than 25 inches in diameter is low in all cover types except mixed conifer, riparian mixed, and lodgepole pine forest.

The Northwest Forest Plan (Forest Service and Bureau of Land Management, 1994) calls for at least 120 linear feet of logs greater than 16 inches diameter and 16 feet in length per acre in the project vicinity. In the project vicinity, only the mixed conifer cover type provides sufficient down wood to meet that standard. Most of the other cover types have low numbers of large downed wood with few areas having logs more than 16 inches diameter.

Riparian communities are important for providing wood to riverine areas for fish and wildlife habitat. In the Klamath River project vicinity, the abundance of coarse woody debris varies substantially among riparian habitats along reservoirs and river reaches. At one extreme, the riparian habitat along the Link River provides no coarse woody debris, and at the other extreme, the riparian habitat along Fall Creek provides 561 feet/acre. The riparian areas along other river reaches were intermediate in log abundance. The Keno reach and the J.C. Boyle bypassed reach had 87 and 119 feet/ acre, respectively, but the reach from Iron Gate dam to the Shasta River reach had only 20 feet/ acre. Much of the J.C. Boyle peaking reach is bordered by forested habitat (either upland or riparian) that can supply the system with logs, but most of the immediate river shoreline is lacking in coarse woody debris. Apparently, logs that reach the river are quickly transported downstream.

In the riparian areas adjacent to reservoir shorelines, log abundance was extremely low. No logs were found at Keno reservoir, and the J.C. Boyle, Copco, and Iron Gate reservoirs each had 12, 8, and 58 feet/acre, respectively. The lack of forested habitat upslope of most of the reservoirs limits the availability of logs along the shoreline. Recreationists also likely reduce the availability of coarse woody debris near recreation sites along reservoirs and river segments.

In and along the margins of the Klamath River, coarse woody debris (large pieces of dead, down wood such as fallen logs, wind blown trees, and large branches) was surveyed at 15 geomorphic study sites within the project boundary and downstream of it. Averaged data for each site shows that coarse woody debris length ranges from 3.3 feet to 32.8 feet; the average diameter ranges from less then an inch to 24 inches; and the average spacing ranges from 16 to 328 feet.

Two study sites downstream of Iron Gate dam had very little coarse woody debris present. The largest (average) coarse woody debris was found at survey sites in the J.C. Boyle peaking reach, where larger oaks and occasional conifers are within one stem-length[98] of the water's edge. PacifiCorp noted that in general, the coarse woody debris at the survey site is not accessible to the channel until periods of higher flows. Along the J.C. Boyle bypassed reach, coarse woody debris is typically colluvial wood from the banks that generally is not accessible by the channel.

[98]Trees that are located within one stem length (the height of the tree) from the edge of the river are capable of entering the channel when they fall, therefore becoming coarse woody debris.

Although substantial deposits of coarse woody debris observed in most project reaches may provide temporary aquatic and riparian habitat, PacifiCorp concluded that surveyed coarse woody debris did not appear to strongly influence underlying geomorphic processes.

Noxious Weeds and Invasive Plants

The Oregon Department of Agriculture (ODA) lists 104 plant species as noxious weeds in Oregon (ODA, 2005) and the California Department of Food and Agriculture (CDFA) lists 133 plant species as noxious weeds in California (CDFA, 2004). Based on literature review and information obtained from ODA, CDFA, the Forest Service, and Bureau of Land Management, PacifiCorp developed a target list of 43 weed species that could occur in the project area. PacifiCorp conducted surveys for noxious weeds in the project vicinity in 2002, 2003, and 2004 in conjunction with its surveys for rare plants, its vegetation cover type verification, and its riparian/wetland vegetation characterization studies. PacifiCorp determined that 21 of the target species occurred in the project vicinity and covered more than 582 acres. PacifiCorp identified and mapped 62 infestations of 15 noxious weed species based on its field surveys and mapped an additional 92 infestations of 18 noxious weed species based on information obtained from the Bureau of Land Management's noxious weed database. Three noxious weed species (cheatgrass, medusahead, and bull thistle) were not mapped because they were found to be so widespread in the project vicinity. Yellow starthistle is the most abundant of the mapped noxious weed species.

PacifiCorp documented several noxious weed species near project facilities where maintenance activities create suitable habitat for invasive species by removing native vegetation or disturbing the ground. Maintenance around facilities is conducted annually and includes both mechanical vegetation removal and spraying. Trees posing a hazard near facilities are cleared as needed. Fire breaks about 10 to 12 feet wide are created annually around campgrounds by using a bulldozer to scrape the ground cover down to mineral soil. Other than standard facility vegetation maintenance, no other fire/fuels management activities are conducted. Substation grounds are kept clear of vegetation. PacifiCorp follows guidelines in its vegetation management plan for managing vegetation in road rights of way.

Special Status Plant Species

PacifiCorp's review of information from the Forest Service, FWS, Bureau of Land Management, ODA, Cal Fish & Game, and the California Native Plant Society (CNPS) indicated that 65 vascular plants, 3 bryophytes, and 10 lichens with special status could potentially occur in the project vicinity. PacifiCorp conducted field surveys for rare plants during May, June, and July 2002, and revisited some sites in October and November of that year and in September 2003 to confirm the identity of plant species potentially with special status. Sixty-seven occurrences of 12 plant species with special status were documented in the project vicinity either during the 2002 surveys or previously by the Bureau of Land Management, ONHP, or the California Natural Diversity database (table 3-80). One of these special status plant species, Applegate's milk-vetch, is federally listed as endangered, and is discussed in section 3.3.5, *Threatened and Endangered Species*.

Table 3-80. Special status plant species that are known to occur in the vicinity of the Klamath Hydroelectric Project. (Source: Cal Fish & Game, 2006a; Oregon Natural Heritage Information Center, 2004; PacifiCorp, 2004a, 2005)

Species	Status[a]	Habitat and Location Where Found
Applegate's milk-vetch (*Astragalus applegate*)	FE, OE, ONHP List 1	Occurs in flat-lying, seasonally moist, strongly alkaline soils. Documented during PacifiCorp's field surveys at Keno reservoir.
Greene's mariposa lily (*Calochortus greenei*)	FSC, BS, OC, ONHP List 1,	Occurs primarily in annual grassland, wedgeleaf ceanothus chaparral, and oak and oak-juniper woodlands.

Species	Status[a]	Habitat and Location Where Found
	CNPS List 2	Documented during PacifiCorp's field surveys at Iron Gate reservoir. Yellow starthistle, medusahead, and annual bromes form the dominant herb layer cover at nearly all of the sites where Greene's mariposa lily was observed. Also known to occur at Copco reservoir and along J.C. Boyle peaking reach.
Mountain lady's slipper (*Cypripedium montanum*)	TS, S/M, ONHP List 4, CNPS List 4	Occurs in dry, open conifer forests, but more often in moist riparian habitats. Documented during PacifiCorp's field surveys on a shaded and mesic, forested slope above Frain Creek, a small tributary to the Klamath River at Frain Ranch along J.C. Boyle peaking reach.
Bolander's sunflower (*Helianthus bolanderi*)	TS, ONHP List 3	Occurs in yellow pine forest, foothill oak woodland, chaparral, and occasionally in serpentine substrates or wet habitats. Documented during PacifiCorp's field surveys in highly disturbed and degraded sites filled with annual bromes and starthistle along the lower reach of Hayden Creek, a tributary to the Klamath River along J.C. Boyle peaking reach, and south of Iron Gate reservoir.
Salt heliotrope (*Heliotropium curvasassavicum*)	AS, ONHP List 2	Occurs in seasonally flooded, low-lying, non-porous areas on the east side of the Cascades. Documented during PacifiCorp's field surveys at the upper end of Keno reservoir.
Bellinger's meadow foam (*Limnanthes floccosa* ssp. b*ellingeriana*)	FSC, BS, OC, ONHP List 1, CNPS List 1B	Occurs in rocky, seasonally wet meadows, or along the margins of damp rocky meadows often partially shaded by adjacent trees and shrubs. Not documented during PacifiCorp's field surveys. Known to occur along J.C. Boyle peaking reach.
Egg Lake monkeyflower (*Mimulus pygmaeus*)	FSC, CNPS List 4	Occurs in damp areas or vernally moist conditions in meadows and open woods. Documented during PacifiCorp's field surveys on the southwest end of J.C. Boyle reservoir in damp mudflats adjacent to shallow and narrow tributaries to the reservoir and under the transmission line just southwest of J.C. Boyle dam.
Red root yampah (*Perideridia erythrorhiza*)	FSC, BS, OC, ONHP List 1	Occurs in moist prairies, pastureland, seasonally wet meadows, and oak or pine woodlands, often in dark wetland soils and clay depressions. Not documented during PacifiCorp's field surveys. Known to occur along Keno reach, at J.C. Boyle reservoir, and along J.C. Boyle peaking reach.
Columbia yellow cress (*Rorippa columbiae*)	FSC, BS, OC, ONHP List 1, CNPS List 1B	Occurs in cobbly, gravelly silt associated with seasonal creek drainages in ponderosa pine/ juniper woodland, on the shores of alkaline lakes, along roadside ditches, in meadows, and seeps. Documented during PacifiCorp's field surveys at Keno reservoir.
Fleshy sage (*Salvia dorrii* var. *incana*)	CNPS List 3	Occurs in silty to rocky soils in great basin scrub, pinyon, and juniper woodland. Documented during PacifiCorp's field surveys on weathered bedrock outcrops overlain

Species	Status[a]	Habitat and Location Where Found
		with thin, loose, and rocky substrate at Iron Gate reservoir and along Klamath River from Iron Gate dam to Shasta River.
Pendulus bulrush (*Scirpus pendulus*)	AS, ONHP List 2, CNPS List 2	Occurs along streambanks and in wet meadows. Documented during PacifiCorp's field surveys along Fall Creek and J.C. Boyle peaking reach.
Short-podded thelypody (*Thelypodium brachycarpum*)	FSC, AS, ONHP List 2, CNPS List 4	Occurs in meadows and open flats. Documented during PacifiCorp's field surveys in low-lying saltgrass grassland at Keno reservoir.

[a] **FE =** Listed as endangered by the FWS.
FSC = Federal species of concern – candidate species the FWS is considering listing under the ESA.
S/M = Survey and Manage Species, Category A and C plant species as defined in the Northwest Forest Plan.
BS = Bureau of Land Management sensitive plant species – species that could easily become endangered or extinct.
AS = Bureau of Land Management assessment plant species – species not presently eligible for federal or state status that may need protection or mitigation.
TS = Bureau of Land Management tracking plant species – more information needed to determine status.
OE = Listed as endangered by ODA.
OC = Candidate for listing by ODA.
ONHP List 1= threatened with extinction or presumed to be extinct throughout their entire range.
ONHP List 2 = threatened with extirpation or presumed to be extirpated from the state of Oregon.
ONHP List 3 = more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range.
ONHP List 4=of conservation concern but not currently threatened or endangered.
CNPS List 1B =rare, threatened, or endangered in California and elsewhere.
CNPS List 2 = rare, threatened, or endangered in California, but more common elsewhere.
CNPS List 3 = on the review list - more information needed
CNPS List 4 = on the watch list - limited distribution

At the time of its field surveys, PacifiCorp documented (by literature review and field surveys) the occurrence of two species in the project vicinity with special status at that time: Howell's yampah (*Perideridia howellii*)[99] and Lemmon's silene (*Lepidium latifolium*).[100] PacifiCorp documented Howell's yampah, which occurs in wet meadows and along stream banks, during its field surveys along the J.C. Boyle peaking reach, along Shovel Creek, and in a small seep at Copco reservoir. The Bureau of Land Management had previously documented Lemmon's silene, which occurs in open pine woodlands, in relatively undisturbed oak and conifer dominated forest along the J.C. Boyle peaking reach, but PacifiCorp did not locate this species in its field surveys.

PacifiCorp conducted surveys for Peck's milk-vetch (*Astragalus peckii*),[101] pumice grapefern (*Botrychium pumicola*),[102] and Ashland thistle (*Cirsium ciliolatum*)[103] but did not locate any occurrences

[99]Previously considered a Bureau of Land Management tracking species and included on the Oregon Natural Heritage Information Center's List 4, but not included on their most current lists.

[100]Previously included on the Oregon Natural Heritage Information Center's List 3, but not on the current list.

[101]Listed as threatened by the Oregon Department of Agriculture and included on the Oregon Natural Heritage Information Center's List 1.

[102]Listed as threatened by the Oregon Department of Agriculture and included on the Oregon Natural Heritage Information Center's List 1.

[103]Considered a sensitive plant species by the Bureau of Land Management and included on the Oregon Natural Heritage Information Center's List 1.

of these species. PacifiCorp determined that potential habitat for Peck's milk-vetch, sandy soils in dry shrublands and sometimes in juniper or pine woodlands, occurs at J.C. Boyle reservoir. Pumice grapefern, which occurs in seasonally moist to dry, alpine, fine to coarse pumice gravels in open pumice fields on treeless ridges and gently rolling slopes, is known to occur along the J.C. Boyle peaking reach and at the Copco and Iron Gate reservoirs. Ashland thistle occurs in dry, rocky grasslands and in open woodlands on south-facing aspects; PacifiCorp determined that potential habitat for this species is located along the Klamath River from the J.C. Boyle peaking reach to the Shasta River.

In its scoping comments, Interior suggested that this EIS should address impacts of roads on pygmy monkey flower (*Mimulus rubellus*). PacifiCorp did not identify pygmy monkey flower as a species that could potentially occur in the project area and therefore, did not conduct surveys for this plant. Pygmy monkey flowers occur in sandy places in washes at elevations of 3,000 to 8,000 feet and have been documented in desert habitats in southeastern and east-central parts of California. It is unlikely that pygmy monkey flower occurs in the Klamath Hydroelectric Project vicinity.

Ethnobotanical Resources

Native American groups in the Klamath River region share a tradition of using botanical resources in the area for food and basketry. Many of the plant species traditionally used by native Americans for food are still found in the vicinity of the Klamath River Project. Klamath and Modoc women dug ipos (*Carum oregonum*) roots and scraped the cambium layers of young ponderosa pines for food. Desert parsley (*Lomatium canbyi*), camas bulbs, and wocas (the nutritious seeds of the yellow pond lily), were also processed into food, as were cattail roots, which were dried and ground into meal. Chokecherries, serviceberries, Klamath plums, pine nuts, blackberries, gooseberries, and huckleberries were also gathered for food.

The Shasta Tribe also used a wide variety of plant products for food, including roots, bulbs, seeds, and berries. In addition to acorns and pine nuts, important roots and bulbs included ipos, redbells, brodiaea, and tiger lily bulbs. Women also collected wild celery, wild parsley, and wild rhubarb for fresh eating, drying, or both. Other vegetal foods included blackberries, elderberries, wild grapes, chokecherries, manzanita and madrone fruits, plums, and grass seeds. Nuts used by the Shasta included acorns from black, white, and canyon live oaks, along with tan oaks that were traded from the Karuk and Yurok tribes. Other nuts included those from gray, ponderosa, and sugar pine, as well as hazelnuts.

Acorns harvested from upland oak groves were also important food sources for the Karuk, Yurok and Hoopa. Traditional foods used by the Karuk Tribe include Indian rhubarb, watercress, and wild turnips from riparian areas, and upland species including red huckleberry, evergreen huckleberry, tan oak, dwarf tan oak, hazel, white oak, canyon oak, and black oak (Norgaard, 2005). Yurok gathered wild sunflower, various bulbs, grass seed and clover, as well as many kinds of fruits and berries, including salmon berry, huckleberry, gooseberry, sallal, currants, and grapes. Plants with cultural and spiritual significance to the Hoopa include willow, cottonwood, wild grape, bulrush, hazel, tules, spearmint and blackberries (King, 2004).

All of the tribes in the Klamath basin continue to collect materials from along the Klamath River for making baskets that are used in various ceremonies. Willow brush is a common basket-making material and fresh willow growth on gravel bars produces the best basket material. Other plant materials used in basket making include pine, redwood and spruce roots, grapevine, and fern.

3.3.4.1.2 Wildlife Resources

The Klamath River valley from Link River to Iron Gate dam is a natural wildlife migration corridor through the Cascade Mountains. The diverse terrain and plant communities support a large number of wildlife species.

Amphibians

PacifiCorp's review of published range maps and habitat associations indicated that 16 amphibian species could occur in the project area. PacifiCorp reviewed existing databases and literature; conducted field surveys in 2002 and 2003 of potential pond-breeding, stream, and terrestrial habitats; and determined that six species of amphibians occur in the project vicinity, including two with special status. Table 3-81 describes the four non-special-status amphibian species. We discuss the two special-status amphibians—the western toad and the foothill yellow-legged frog—later in this section.

Table 3-81. Non-special status amphibian species that are known occur in the vicinity of the Klamath Project. (Source: PacifiCorp, 2004a, 2005a)

Species	Habitat and Location Where Found
Pacific treefrog (*Hyla regilla*)	Inhabits marshes, mountain meadows, woodlands, brush, and disturbed areas, breeding in water less than 1.6 feet deep in permanent or seasonal pools; tadpoles live in shallow water while froglets occur in vegetation along the perimeter of ponds. Documented by the Bureau of Land Management in its surveys in 2000 and 2001 along the Klamath River in pine and mixed-conifer woodlands, as well as in non-forested habitats. The Bureau of Land Management also documented breeding Pacific treefrogs at a number of widely scattered locations in Oregon portion of J.C. Boyle peaking reach. In its surveys, PacifiCorp documented breeding sites in wetlands directly connected to J.C. Boyle peaking reach and Iron Gate reservoir.
Bullfrog (*Rana catesbiana*)	Not native to Oregon or California but occurs throughout much of the project vicinity, inhabiting very warm and sunny permanent ponds, marshes, and slow river backwaters. Lays eggs in ponds during the summer, and tadpoles occupy shallow water with dense aquatic vegetation; froglets, and adults require permanent water with dense submerged, emergent, and shoreline vegetation. Reported by Oregon Fish & Wildlife along Link River. Documented by PacifiCorp in its surveys along Keno reservoir, at J.C. Boyle reservoir, in J.C. Boyle bypassed reach, in the uppermost portion of J.C. Boyle peaking reach, at Copco reservoir, at Iron Gate reservoir, along Jenny Creek (0.25 mile upstream of Iron Gate reservoir), and at two locations downstream of Iron Gate dam. This species likely breeds in all project reservoirs, in slow-moving sections of river reaches, and at other sites and creates substantial predatory pressure on native amphibians and small fish.
Pacific giant salamander (*Dicamptoden tenebrosus*)	Inhabits cool, moist forests adjacent to streams and lakes and are also found in moist talus. Neonates prefer Order III-V streams; larva are typically found in Order II-V streams, but will use Order I. May be found in low to moderate gradient tributaries with pool morphology and rocky bottoms. In its surveys, PacifiCorp found larval forms of Pacific giant salamanders above and below Fall Creek diversion dam as well as in J.C. Boyle bypassed reach.
Long-toed salamander (*Ambystoma macrodactylum*)	Inhabits a wide variety of habitats including forests, grasslands, and disturbed areas. Eggs are laid in water less than 1.6 feet deep in seasonal pools, along shallow lake edges, and in slow streams through wet meadows; hatchlings and larvae live in sediments in shallow water. Adults stay underground, but can be found under logs and rocks during the rainy season. Documented by PacifiCorp in its surveys in the stock pond southwest of Topsy Campground, on the south side of J.C. Boyle reservoir and in the Long Prairie stock pond north of Copco reservoir along Long Prairie Creek.

Reptiles

PacifiCorp's review of published range maps and habitat associations indicated that 22 reptile species could occur in the project area. PacifiCorp reviewed existing databases and literature; conducted field surveys in 2002 and 2003 of potential pond-breeding, stream, and terrestrial habitats; and determined that 16 species of reptiles occur in the project vicinity, including four with special status. We address the 12 non-special-status species in table 3-82 and the special-status species later on in this section.

Table 3-82. Non-special status reptile species that are known to occur in the vicinity of the Klamath Project. (Source: PacifiCorp, 2004a, 2005)

Species	Habitat and Location Where Found
Northern alligator lizard (*Elgaria coerulea*)	Inhabits the edges of meadows in coniferous forests and in riparian zones. PacifiCorp documented it during its surveys in proximity to J.C. Boyle powerhouse intake canal.
Southern alligator lizard (*Elgaria multicarinata*)	Occurs in thickets, logs, or rock piles in grasslands, chaparral, oak woodlands, edges of conifer forests, riparian areas, and moist canyon bottoms. The Bureau of Land Management documented it in its 2000 and 2001 surveys in hardwood woodlands and in non-forested habitats along the Klamath River throughout J.C. Boyle peaking reach, particularly downstream of Frain Ranch on southern aspects. Documented by PacifiCorp in its surveys in montane hardwood oak-conifer forests along J.C. Boyle peaking reach and in riparian and wetland habitats along Keno and J.C. Boyle peaking reaches, and Copco reservoir.
Western skink (*Eumeces skiltonianus*)	Inhabits moist sites under rocks and logs in grassland, chaparral, juniper woodlands, conifer forests, and riparian areas. The Bureau of Land Management documented it in its 2000 and 2001 surveys at seven locations along Klamath River in conifer, hardwood, and Douglas-fir woodlands, including two sites immediately north of the river just upstream of the California-Oregon border and at other widely scattered sites 0.2 to 0.8 mile from the river. PacifiCorp documented it in its surveys in riparian grass habitat along J.C. Boyle bypassed reach.
Western fence lizard (*Sceloporus occidentalis*)	Inhabits a wide range of habitats, but requires vertical structure. The Bureau of Land Management documented it in its field surveys in 2000 and 2001 along Klamath River in pine, hardwood, Douglas fir, and mixed conifer woodlands as well as in non-forested habitats. It was the most abundant reptile species encountered by PacifiCorp in its field surveys. PacifiCorp documented it in a wide variety of habitats including riparian and wetland, mixed chaparral, juniper, montane hardwood oak woodlands, ponderosa pine forest, mixed conifer forest, and lodgepole pine stands throughout the project vicinity except at Link River. Also found by PacifiCorp in proximity to J.C. Boyle powerhouse intake canal.
Rubber boa (*Charina bottae*)	Commonly found in forest openings with stumps and logs, but also in forested areas and grasslands. The Bureau of Land Management documented this species in its 2000 and 2001 surveys along Klamath River in mixed-conifer woodlands. Not documented by PacifiCorp in its surveys.
Yellow-bellied racer (*Coluber constrictor*)	Occurs in sagebrush flats, juniper woodlands, chaparral, and meadows; avoids dense forests. The Bureau of Land Management documented it in its 2000 and 2001 field surveys along Klamath River in pine, Douglas-fir, non-forested, hardwood, and mixed conifer woodlands. PacifiCorp documented it in its surveys along J.C. Boyle peaking reach, in pasture and in riparian habitat. Also found by PacifiCorp in proximity to J.C. Boyle powerhouse intake canal.

Species	Habitat and Location Where Found
Western rattlesnake (*Crotalis viridus*)	Found in areas with low or sparse vegetation and rocky areas; known to occur throughout the project vicinity, with a patchy distribution. Reported along various sections of J.C. Boyle peaking reach. Documented by the Bureau of Land Management in its surveys in hardwood woodlands and in non-forested habitats along the Klamath River between the J.C. Boyle dam and the Oregon-California border. PacifiCorp documented it in its surveys in riparian and wetland habitat along J.C. Boyle bypassed reach and at Iron Gate reservoir. Also observed by PacifiCorp on roads either basking or already killed by vehicles and in proximity to J.C. Boyle powerhouse intake canal.
Ring-necked snake (*Diadophis punctatus*)	Inhabits moist conditions under wood, rocks, talus, or woody debris and are known to occur in riparian habitats with a deciduous overstory. Surface activity is limited, with most activity occurring from March to mid-May. Documented by the Bureau of Land Management in its 2001 surveys at one location approximately 0.1 mile west of Klamath River and northwest of Frain Ranch in hardwood woodlands. PacifiCorp documented it in its surveys near J.C. Boyle powerhouse intake canal.
Striped whipsnake (*Masticophis taeniatus*)	Occurs in grasslands, sagebrush, rocky stream courses, and canyon bottoms, as well as juniper and pine-oak woodlands. The Bureau of Land Management documented it in its 2000 and 2001 field surveys along Klamath River in pine and non-forest habitats, near Keno dam, and 0.5 mile north of the Klamath River not far from the California-Oregon border. In its surveys, PacifiCorp found one striped whipsnake dead on the county road near Copco village in montane hardwood oak habitat. PacifiCorp also provided anecdotal reports of observations along the Copco Road just northeast of Fall Creek powerhouse.
Gopher snake (*Pituophis melanoleucus*)	Inhabits a wide variety of habitats. The Bureau of Land Management documented it in its field surveys in 2000 and 2001 along Klamath River from the J.C. Boyle dam to the Oregon-California border in pine, hardwood, and mixed-conifer woodlands. PacifiCorp documented it in its surveys of riparian habitat at Keno reservoir, along Keno reach, along J.C. Boyle peaking reach, and along Klamath River from Iron Gate dam to Shasta River. Also observed by PacifiCorp on roads either basking or already killed by vehicles.
Western terrestrial garter snake (*Thamnophis elegans*)	Inhabits a wide variety of habitats. The Bureau of Land Management documented it in its 2000 and 2001 field surveys along Klamath River from the J.C. Boyle dam to the Oregon-California border in ponderosa pine, hardwood, and mixed-conifer woodlands, as well as non-forested habitats. PacifiCorp documented it in surveys of riparian habitat along J.C. Boyle peaking reach and at Fall Creek diversion dam.
Common garter snake (*Thamnophis sirtalis*)	Inhabits a wide variety of habitats. The Bureau of Land Management documented it in its field surveys in 2000 and 2001 along Klamath River from the J.C. Boyle dam to the Oregon-California border in ponderosa pine and mixed-conifer woodland, and non-forested habitats. Documented by PacifiCorp in its surveys in riparian habitats along Link River, and Keno, J.C. Boyle bypassed, and J.C. Boyle peaking reaches. PacifiCorp also documented one winter hibernaculum with numerous common garter snakes just downstream of Keno dam among concrete rubble about 20 feet from the Klamath River.

Birds

PacifiCorp conducted avian plot surveys, facility surveys, and reservoir surveys, and also reviewed Klamath Bird Observatory data from avian censuses and mist-netting conducted in the project vicinity. PacifiCorp found birds in all habitats surveyed in the project vicinity. Habitats with the lowest

avian relative abundance were rock talus and mixed riparian habitats; habitats with the highest relative abundance were sagebrush, wetlands, and pastures.

PacifiCorp documented 93 passerine species, and seven were found at all of the project reservoirs and in all of the project reaches: western wood pewee, song sparrow, yellow warbler, brown-headed cowbird, black-headed grosbeak, Brewer's blackbird, and mourning dove. All seven species are associated with riparian and/or wetland habitat. PacifiCorp found 4 of the 93 passerine species in or near the disturbed habitats around project facilities: cliff swallow, Brewer's blackbird, red-winged blackbird, and brown-headed cowbird. PacifiCorp found that species relatively abundant in riparian and wetland habitats throughout the project area include red-winged blackbird, song sparrow, and yellow warbler.

Project reservoirs are important for many waterfowl and water-related birds. Approximately 67 percent of all birds documented by PacifiCorp during its field surveys were waterfowl and other water-related birds. PacifiCorp observed 47 species of water birds including 20 species of waterfowl and 19 species of open-water, marsh, and wading birds other than waterfowl. Five of the waterfowl species are permanent or summer residents and have been documented breeding near the project: Canada goose, wood duck, mallard, blue-winged teal, and common merganser. PacifiCorp observed wood duck and common merganser broods during waterfowl surveys of the reservoirs and other surveys of river reaches.

During its field surveys PacifiCorp also documented:

- Nineteen species of birds of prey, including six species of hawk, two eagle species, three falcon species, seven owl species, and one species of vulture.
- Eight species of woodpeckers, including acorn woodpecker, white-headed woodpecker, Lewis' woodpecker, red-shafted flicker, red-breasted sapsucker, downy woodpecker, hairy woodpecker, and pileated woodpecker.
- Five gamebird species, including wild turkey, blue grouse, California quail, mountain quail, and mourning dove.

Mammals

PacifiCorp conducted track surveys, photographic bait station surveys, and wildlife surveys near project facilities as well as live trapping for small mammals on each side of the West Side, J.C. Boyle, and Fall Creek canals. PacifiCorp also documented incidental observations of mammals throughout the project vicinity. PacifiCorp observed a total of 30 mammals in the project vicinity; black-tailed jackrabbit, deer, and California ground squirrels occurred throughout the project vicinity.

Big Game. Big game mammals in the project vicinity include mule deer, black-tailed deer, elk, black bear, and cougar. Oregon Fish & Wildlife manages these species in Oregon, and Cal Fish & Game manages them in California primarily for sport-hunting purposes.

Mule deer typically occur to the east of the Cascade crest, and black-tailed deer occur to the west. However, within the project vicinity, hybrid deer may be the most common. Oregon Fish & Wildlife does not distinguish between the two species when managing populations on the Keno Wildlife Management Unit, north of the Klamath River in Oregon. Oregon Fish & Wildlife's winter deer population goal at this management unit is 3,200 individuals (Oregon Fish & Wildlife, 2003b); Oregon Fish & Wildlife estimates that approximately 1,200 deer currently winter in the Keno Wildlife Management Unit, and most of them are also residents during the summer. In California, the Cascade-North Sierra Nevada Deer Assessment Unit extends from the Oregon border south to Lake Almanor and the Feather River drainage. In this area, the deer population has declined due to loss of high quality early-successional habitat and a hard freeze several years ago that killed desirable browse in the summer range.

The Bureau of Land Management, Oregon Fish & Wildlife, and Cal Fish & Game consider the canyon and mid-elevation hillsides and plateaus between the J.C. Boyle powerhouse and Iron Gate dam

as critical deer winter range. This area represents one of the largest contiguous areas of winter range in the southern Oregon and northern California region. In the project vicinity, south-facing lower canyon walls and hillsides are some of the most critical habitat for wintering migratory black-tailed deer herd as well as for resident deer.

Several acres of habitat with wedgeleaf ceanothus and mountain mahogany, major deer browse species, occur within the project vicinity. These two shrub species are estimated to be a major component in 14 vegetation cover types occurring in the project vicinity. There is a substantial amount of desirable browse along the J.C. Boyle peaking reach, along the Copco No. 2 bypassed reach, and along Fall Creek.

Oregon Fish & Wildlife's winter management objective for elk at the Keno Wildlife Management Unit is 700 elk; currently, about 400 elk winter there. Most elk have an affinity for certain ranges and generally will use the same summer and wintering grounds throughout their life (Oregon Fish & Wildlife, 2003a). The severity of winter often will influence how far and to what elevation elk will move to avoid adverse weather conditions. Studies in the central Oregon Cascades have shown that elk often winter on the west slope of the Cascades and cross to central Oregon in the summer. Elk are known to have summer ranges west of Upper Klamath Lake in Oregon and in the upper portions of the Long Prairie Creek and Jenny Creek watersheds, as well as several areas at higher elevations north of the river. No data exist on elk wintering near the project reservoirs. Based on previous studies, a small number of elk may cross into the project vicinity during migration periods, but elk do not appear to remain close to project reservoirs for long periods of time during any season. During its field surveys, PacifiCorp observed two elk along the J.C. Boyle peaking reach.

The black bear is a resident of most forested ecosystems in southern Oregon and northern California. PacifiCorp documented black bear during its field surveys along the Link River and along the J.C. Boyle bypassed reach. Oregon Fish & Wildlife considers bear density in the project vicinity as medium on the eastern end of the project and high on the western end. Cal Fish & Game expects bear populations to be highest in montane hardwood, montane chaparral, and mixed conifer forests.

The mountain lion commonly occurs in most habitats in the project vicinity. During its field surveys PacifiCorp documented mountain lions along the J.C. Boyle bypassed reach, the J.C. Boyle peaking reach, and along the Copco No. 2 bypassed reach. The state of Oregon classifies the mountain lion as a game mammal and gives Oregon Fish & Wildlife management responsibility (Oregon Fish & Wildlife, 2006). The 2006 mountain lion harvest quota for the southwest Cascades region of Oregon is 173 individuals (the highest of any region in Oregon). In California, the mountain lion is a specially protected mammal, and no take is allowed except under depredation/nuisance circumstances.

Other Mammals. During its field surveys, PacifiCorp documented five aquatic fur-bearing mammal species in the project vicinity including raccoon, beaver, muskrat, mink, and river otter. Mink and raccoons are common throughout the project vicinity along the Klamath River and its tributaries. Muskrats are particularly common along the Keno reservoir and the adjacent Klamath Wildlife Area, where large patches of emergent wetland provide ample habitat. PacifiCorp documented river otters or their sign downstream of the J.C. Boyle and Iron Gate dams, and in the beaver pond wetlands near Copco village. Beaver sign is common along all river reaches and in the portions of project reservoirs where there are well-developed riparian and wetland habitats, such as along Spencer Creek on the J.C. Boyle reservoir and near Jenny and Camp creeks on the Iron Gate reservoir.

Medium-sized mammals that PacifiCorp documented in the project vicinity include bobcat, gray fox, yellow-bellied marmot, and coyote. Yellow-bellied marmots were only found at the Link River and at the Keno reservoir. The other species were found throughout the project vicinity.

During its field surveys, PacifiCorp also documented several small mammal species. It identified in particular the deer mouse, bushy-tailed woodrat, dusky-footed woodrat, montane vole, canyon mouse, and least chipmunk.

PacifiCorp reported that a wild horse herd roams throughout the area from near Fall Creek to near J.C. Boyle dam. This herd is known as the Pokegama Wild Horse Herd and occurs primarily on a formally established wild horse herd management area controlled by the Bureau of Land Management. The Bureau of Land Management's goal is to keep the herd near 30 animals, but no accurate population estimate is currently available.

PacifiCorp also reported that local ranchers have seen wild pigs near the Klamath River during the last several decades. PacifiCorp did not find any evidence of wild pigs during its field surveys.

Special Status Wildlife Species

PacifiCorp conducted a search of federal and state databases of wildlife with special status and consulted with agency (Forest Service, FWS, Bureau of Land Management, Oregon Fish & Wildlife, and Cal Fish & Game) biologists familiar with special status species locations and determined that 107 vertebrate species and 22 invertebrate species with special status could potentially occur in the project vicinity. PacifiCorp conducted field surveys for rare vertebrate and invertebrate wildlife species in the project vicinity during 2002 and 2003 and documented 45 of the 107 vertebrate species with special status, including one amphibian, four reptiles, 38 birds, and two mammals. Two of these special status vertebrate species, the federally listed as threatened northern spotted owl and the recently delisted bald eagle, are discussed in section 3.3.5, *Threatened and Endangered Species*. The amphibians, reptiles, birds, and mammals shown in table 3-83 include federal species of concern and state-listed threatened, endangered, or species of concern that have been documented in the project vicinity either by PacifiCorp, the Bureau of Land Management, Oregon Fish & Wildlife, or Cal Fish & Game. The current status of each species was identified after reviewing Oregon Fish & Wildlife's and Cal Fish & Game's current lists of special-status animals. Table 3-84 provides the status information for each special status species and summarizes the typical habitat for each of these species and their occurrence in the project vicinity.

Table 3-83. Special status species that are known or documented to occur in the Klamath Project vicinity. (Source: Bureau of Land Management, 2006a; Cal Fish & Game, 2005, 2006b; Oregon Fish & Wildlife, 2005a, 2005b; Oregon Natural Heritage Information Center, 2004; PacifiCorp, 2004a, 2005)

Species	Status[a]	Habitat and Location Where Found
Amphibians		
Western toad *Bufo boreas*	Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4	Breeds from February to early May in ponds, the edges of shallow lakes, and in slow-moving streams where the water depths are less than 1.6 feet deep and the water temperature is at least6°C; hatchlings and tadpoles live in the warmest water available, up to30°C; adults are common near marshes and small lakes but may also be found in dry forests, shrubby areas, and meadows. Documented during PacifiCorp's surveys along J.C. Boyle peaking reach, along the north shore of Iron Gate reservoir, and along Klamath River near RM 185 (between the confluence of Bogus and Cottonwood creeks).

Species	Status[a]	Habitat and Location Where Found
Foothill yellow-legged frog *Rana boylii*	FSC, Bureau of Land Management-A, Oregon Fish & Wildlife SV, ONHP List 2, Cal Fish & Game SSC	Inhabits permanent slow-moving streams with rocky bottoms in a variety of habitats, including large cobble bars or in-channel islands, coupled with slower backwater areas for larval rearing. Not documented during PacifiCorp's surveys. Known to occur along J.C. Boyle bypassed reach near J.C. Boyle dam.
Reptiles		
Northwestern pond turtle *Clemmys marmorata marmorata*	FSC, Bureau of Land Management, Oregon Fish & Wildlife SC, ONHP List 2, Cal Fish & Game SSC	Prefers quiet water in small lakes, marshes, and sluggish streams and rivers; requires basking sites, such as logs, rocks, mud banks, or cattail mats; nests in open canopy sites with loose soil; home range of 0.6 to 2.4 acres. Documented during PacifiCorp's surveys at Keno, J.C. Boyle, Copco, and Iron Gate reservoirs, along J.C. Boyle bypassed reach, along J.C. Boyle peaking reach in California, and along Klamath River from Iron Gate dam to Shasta River.
Northern sagebrush lizard *Sceloporus graciosus graciosus*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4	Inhabits sagebrush, chaparral, juniper woodlands, and dry conifer forests. Documented during PacifiCorp's surveys in the rocky riparian shrub habitat of Keno reach, along J.C. Boyle peaking reach, near J.C. Boyle powerhouse intake canal, and near the edge of a forested wetland along Iron Gate reservoir.
Sharptail snake *Contia tenuis*	Bureau of Land Management-T	Inhabits moist sites in chaparral, conifer forests, and deciduous forests, but primarily occurs in oaks and other deciduous tree woodlands, particularly in the forest edges. Active from March to mid-May. Known to occur along upper J.C. Boyle peaking reach west of Frain Ranch in Douglas-fir habitat but not detected by PacifiCorp during its surveys.
Common kingsnake *Lampropeltis getula*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4	Inhabits thick vegetation along watercourses, farmland, chaparral, deciduous, and mixed-coniferous forests; specifically associated with moist river valleys and dense riparian vegetation. Relatively wide-ranging in California, but have been reported to occur in Oregon only within the inland valleys of Douglas, Jackson, and Josephine counties. Documented during PacifiCorp's surveys along J.C. Boyle peaking reach in oak/woodland and mixed-conifer woodland and along Copco Road.
California mountain kingsnake *Lampropeltis zonata*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4	Occurs in pine forests, oak woodlands, and chaparral in, under, or near rotting logs and usually near streams; associated with well-illuminated rocky riparian habitat with mixed deciduous and coniferous trees, especially canyon live oak and black oak. Documented during PacifiCorp's surveys along Copco Road and in close proximity to J.C. Boyle powerhouse intake canal. Also known to occur in mixed-conifer woodlands along J.C. Boyle peaking reach.

Species	Status[a]	Habitat and Location Where Found
Birds		
Common loon *Gavia immer*	FSC, Cal Fish & Game SSC-HP	May over-winter on project reservoirs or occur in aquatic habitat associated with large bodies of water like the project reservoirs while migrating from sub-arctic freshwater breeding grounds to coastal and near-shore pelagic marine habitat along the Pacific coast. Documented during PacifiCorp's surveys at Iron Gate reservoir.
American white pelican *Pelecanus erythrorhynchos*	Bureau of Land Management-A, Oregon Fish & Wildlife SV, ONHP List 2, Cal Fish & Game SSC-HP	Nests at lakes and marshes and uses almost any lake outside of the breeding season; have a restricted range in southern Oregon and along the California border, where they are found to be associated with only a few large bodies of inland water. Documented during PacifiCorp's surveys on all project reservoirs, with the highest number occurring on Keno reservoir, and along Link River, Keno reach, J.C. Boyle bypassed reach, and on Klamath River between Iron Gate dam and Shasta River.
Black-crowned night heron *Nycticorax nycticorax*	FSC	Found in riparian habitats and in wetland sites. Communal roost used by night herons and other heron species located in a group of willow trees near the East Side powerhouse adjacent to Link River. Documented during PacifiCorp's surveys primarily along Keno reach, but also along Link River, at Keno reservoir, and along Klamath River from Iron Gate dam to Shasta River.
Snowy egret *Egretta thula*	Bureau of Land Management-A, Oregon Fish & Wildlife SV, ONHP List 2	Inhabits emergent wetlands associated with freshwater marshes and along the periphery of large water bodies. The northern limit of the snowy egret's range includes the area along the border between California and Oregon and southern Oregon. Documented during PacifiCorp's surveys near Link River dam, at Keno dam, and along Keno reach.
White-faced ibis *Plegadis chihi*	FSC, Bureau of Land Management-T, ONHP List 4, Cal Fish & Game SSC-HP	Breeds in freshwater marshes and lakes, and estuaries, and nests near the water on mats of vegetation and twigs; usually occurs in isolated con-specific flocks. Does not typically overwinter in Oregon but is a fairly common visitor in the Klamath Wildlife Area during the spring and summer. Documented during PacifiCorp's surveys along Link River and at Keno and J.C. Boyle reservoirs.
Barrow's goldeneye *Bucephala islandica*	Oregon Fish & Wildlife SU, ONHP List 4, Cal Fish & Game SSC-TP	Tends to breed along high-elevation mountain lakes and winter in coastal areas. Potential nesting habitat includes forests with sparse to moderate tree canopy closure next to rivers and reservoirs. Documented during PacifiCorp's surveys along Keno reservoir, in an inundated drainage ditch off of Copco reservoir, and on Iron Gate reservoir.
Bufflehead *Bucephala albeola*	Bureau of Land Management-A, Oregon Fish & Wildlife SU, ONHP List 4	Typically breeds around isolated mountain lakes; nesting habitat includes mixed conifer forest and ponderosa pine forests with sparse to moderate tree canopy closure close to lakes and ponds. Nests in cavities, including artificial nest boxes. May be found in open water and riverine habitat throughout southern Oregon after the breeding season. Documented during PacifiCorp's surveys primarily from January until April along the Link River, at Keno, Copco, and Iron Gate reservoirs.

Species	Status[a]	Habitat and Location Where Found
Osprey *Pandion haliaetus*	Cal Fish & Game SSC-SP	Nests in all forested vegetation types with large trees near water, as well as on platforms erected in less optimal habitat. A minimum of 16 active osprey nests, both artificial nesting platforms and natural sites, are located along the shores of the project reservoirs and river reaches. Documented during PacifiCorp's surveys along the Keno reach, along the J.C. Boyle bypassed reach, along the J.C. Boyle peaking reach, at J.C. Boyle, Copco, and Iron Gate reservoirs, along Fall Creek, and along Klamath River from Iron Gate dam to Shasta River.
Northern harrier *Circus cyaneus*	Cal Fish & Game SSC-SP	Nests and forages in grasslands and emergent wetlands. Permanent residents in the project vicinity and common at the Klamath Wildlife Area. Documented during PacifiCorp's surveys in the low-lying marshland and agricultural fields east of Keno reservoir and along Klamath River from Iron Gate dam to Shasta River.
Golden eagle *Aquila chrysaetos*	Cal Fish & Game SSC-TP	Breeds in open mountain and hill habitats, nests on cliff ledges, and forages in grasslands and open conifer forests and woodlands with sparse to open tree canopy closure. Eagles use two to three nests during a lifetime. Historical records exist of several golden eagle nests located on cliffs from J.C. Boyle bypassed reach to Iron Gate reservoir. Documented during PacifiCorp's surveys at J.C. Boyle powerhouse, along the lower section of J.C. Boyle peaking reach, along Copco and Iron Gate reservoirs, and Copco bypassed reach.
Bald eagle *Haliaeetus leucocephalus*	Oregon Fish & Wildlife LT, ONHP List 4, CFGC LE	Nests in large conifers within several miles of water; forages in rivers and lakes for fish and waterfowl; requires large snags for perching and conifers for night roosts. Documented during PacifiCorp's surveys at all project reservoirs and in all project reaches throughout the project vicinity.
Sharp-shinned hawk *Accipiter striatus*	Cal Fish & Game SSC-TP	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure and tree diameters ranging from 6 to 24 inches. Documented during PacifiCorp's surveys in oak habitat along J.C. Boyle bypassed and peaking reaches, and along Klamath River from Iron Gate dam to Shasta River.
Cooper's hawk *Accipiter cooperii*	Cal Fish & Game SSC-TP	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak-juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure. Documented during PacifiCorp's surveys along J.C. Boyle bypassed and peaking reaches, and along Klamath River from the Iron Gate dam to Shasta River.

Species	Status[a]	Habitat and Location Where Found
Northern goshawk *Accipiter gentilis*	FSC, Bureau of Land Management, CC, Oregon Fish & Wildlife SC, ONHP List 4, Cal Fish & Game SSC-TP	Inhabits forested communities with at least 60 percent canopy cover and trees greater than 6 inches in diameter, except oak woodland, oak-conifer woodland, and oak-juniper woodland; forages over large home ranges. Documented during PacifiCorp's surveys flying over J.C. Boyle peaking reach.
Swainson's hawk *Buteo swainsoni*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4, Cal Fish & Game SSC-HP, CFGC LT	Dwells in open country and typically inhabits sagebrush, annual grassland, juniper woodland, montane hardwood oak-juniper, and riparian deciduous forest with sparse to open tree canopy closure. The species' range generally lies east of the project vicinity and includes the plains of the Great Basin in southeast Oregon and eastern northern California. Documented during PacifiCorp's surveys flying over agricultural fields southeast of Keno reservoir.
Merlin *Falco columbarius*	Bureau of Land Management-A, ONHP List 2, Cal Fish & Game SSC-HP	Uses a variety of forested and open habitats. Ranges throughout North America and travels great distances during migration from breeding grounds in northern Canada and Alaska to wintering habitat through the contiguous United States south to Central America. Documented during PacifiCorp's surveys at J.C. Boyle reservoir and along J.C. Boyle peaking reach.
Prairie falcon *Falco mexicanus*	Cal Fish & Game SSC-TP	Uses cliffs for nesting and plateau grasslands for foraging. Documented during PacifiCorp's surveys near Keno reservoir campground and boat ramp, above J.C. Boyle bypassed reach, near Copco reservoir, and flying over Klamath Wildlife Refuge.
American peregrine falcon *Falco peregrinus anatum*	Bureau of Land Management-S, CC, OFWC LE, ONHP List 2, CFGC LE	Breeds at suitable nest sites on cliffs and rocky outcroppings. Uses a variety of habitats, including open grassland areas, forest stands, and reservoirs throughout the project vicinity. The project vicinity is located in a management area designated for peregrine falcon recovery. Known to occur along Keno reservoir and the J.C. Boyle bypassed reach but not documented during PacifiCorp's surveys.
Mountain quail *Oreortyx pictus*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SU, ONHP List 4	Inhabits open forests, chaparral, and juniper woodlands with dense undergrowth offering suitable refuge; breeds in higher elevation areas; migrates on foot up to 40 miles to lower elevation winter grounds. Documented during PacifiCorp's surveys at J.C. Boyle reservoir, along the J.C. Boyle bypassed reach and peaking reaches, along Fall Creek, and along Klamath River from the Iron Gate dam to Shasta River.
Greater sandhill crane *Grus canadensis tabida*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SV, ONHP List 4, CFGC LT, Cal Fish & Game SSC-TP	Nests in marshes and wet meadows, and occasionally in pastures and irrigated hayfields. A primary requirement for suitable nesting habitat is the presence of surrounding water or undisturbed habitat. Documented during PacifiCorp's surveys east of Keno reservoir and along J.C. Boyle reservoir. PacifiCorp located an active nest with two eggs in it in the emergent wetland bordering J.C. Boyle reservoir.

Species	Status[a]	Habitat and Location Where Found
Caspian tern *Sterna caspia*	CC	Nests in tightly packed colonies on undisturbed islands, levees, and shores along inland water bodies during the summer breeding season and migrates south to winter from southern California through Central America. Forages over water. Documented during PacifiCorp's surveys on all project reservoirs as well as along Link River, Keno and J.C. Boyle bypassed reaches, and along the Klamath River from Iron Gate dam to Shasta River.
Forster's tern *Sterna forsteri*	Bureau of Land Management-T, ONHP List 4	Breeds at lakes and marshes and on mud or sand flats near water; forages over water. Documented during PacifiCorp's surveys along Link River, along Keno and J.C. Boyle bypassed and peaking reaches, and at all project reservoirs.
Black tern *Chlidonias niger*	FSC, Bureau of Land Management-T, ONHP List 4, Cal Fish & Game SSC	Nests in emergent vegetation along the shoreline periphery of freshwater lakes, wetlands, and marshes along rivers and ponds; forages in wet meadows, pastures, agricultural fields, and water. Documented during PacifiCorp's surveys at Keno and J.C. Boyle reservoirs.
Great gray owl *Strix nebulosa*	Bureau of Land Management-T, S/M-C, Oregon Fish & Wildlife SV, ONHP List 4, CFGC LE	Inhabits mixed conifer, ponderosa pine, and riparian mixed forest stands with trees greater than 11 inches in diameter providing at least 60 percent canopy cover within at least 984 feet of a natural or manmade opening greater than 10 acres. Breeds in tree cavities, typically located near suitable open grassland foraging habitat. Documented during PacifiCorp's surveys east of Fall Creek near Jenny Creek.
Northern spotted owl *Strix occidentalis caurina*	FT, OFWC LT, ONHP List 1	Inhabits ponderosa pine forest and mixed conifer forest with trees greater than 11 inches in diameter. Prefers old-growth forests with multi-layered tree canopies. Documented during PacifiCorp's surveys near J.C. Boyle reservoir and along J.C. Boyle peaking reach.
Flammulated owl *Otus flammeolus*	Bureau of Land Management, CC, Oregon Fish & Wildlife SC, ONHP List 4	Nests in abandoned woodpecker nest cavities in open forests with a ponderosa pine component. Documented during PacifiCorp's surveys along J.C. Boyle bypassed and peaking reaches.
Vaux's swift *Chaetura vauxi*	Cal Fish & Game SSC	Found in mixed conifer, ponderosa pine, lodgepole pine, riparian deciduous, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper forests with trees greater than 11 inches in diameter. Documented during PacifiCorp's surveys at J.C. Boyle, Copco, and Iron Gate reservoirs, along the J.C. Boyle bypassed and peaking reaches, along Fall Creek, and along Klamath River from Iron Gate dam to Shasta River.
Acorn woodpecker *Melanerpes formicivorous*	FSC, Bureau of Land Management-T, ONHP List 4	Nests in cavities located in snags of deciduous tree species, particularly oak snags at least 17 inches in diameter. PacifiCorp documented several nesting colonies in oak, oak-juniper, and oak-conifer habitats, primarily at Copco reservoir. Also documented during PacifiCorp's surveys at J.C. Boyle and Iron Gate reservoirs, along J.C. Boyle peaking reach, along Copco bypassed reach, along Fall Creek, and along Klamath River from Iron Gate dam to Shasta River.

Species	Status[a]	Habitat and Location Where Found
White-headed woodpecker *Picoides albolarvatus*	FSC, Bureau of Land Management, CC, Oregon Fish & Wildlife SC, ONHP List 2	Nests in cavities typically located in ponderosa pine at least 18 inches in diameter. Occurs in lodgepole pine, ponderosa pine, and Klamath mixed conifer forests with trees greater than 11 inches in diameter. Documented during PacifiCorp's surveys along J.C. Boyle bypassed reach.
Lewis' woodpecker *Melanerpes lewis*	FSC, Bureau of Land Management-A, CC, Oregon Fish & Wildlife SC, ONHP List 2	Associated with oak woodlands and mixed oak conifer habitat, but also can be found in a variety of open forest stands including ponderosa pine and cottonwood-dominated riparian areas. Documented during PacifiCorp's surveys in upland habitats along J.C. Boyle peaking reach, in riparian habitats at Iron Gate reservoir, and along Klamath River from Iron Gate dam to Shasta River.
Williamson's sapsucker *Sphyrapicus thyroideus*	Bureau of Land Management-T, Oregon Fish & Wildlife SU	Associated with higher-elevation coniferous forest types including ponderosa pine, lodgepole pine, and Douglas-fir. Known to occur in the general project vicinity but not documented during PacifiCorp's surveys.
Pileated woodpecker *Dryocopus pileatus*	Bureau of Land Management-T, Oregon Fish & Wildlife SV	Occurs in all forest and woodland cover types with moderate to dense tree canopy closure. Requires large snags 25 inches or more in diameter for excavating suitable nest cavities. Documented during PacifiCorp's surveys along Keno reach, at J.C. Boyle reservoir, along J.C. Boyle bypassed and peaking reaches, and along Fall Creek.
Olive-sided flycatcher *Contopus cooperi*	FSC, Bureau of Land Management-T, CC, Oregon Fish & Wildlife SV, ONHP List 4	Typically found in coniferous forests with tall trees providing suitable perch sites. Documented during PacifiCorp's surveys along Link River, at Keno, J.C. Boyle and Iron Gate reservoirs, and along Keno and J.C. Boyle peaking reaches.
Willow flycatcher *Empidonax traillii adastus*	FSC, Bureau of Land Management-T, Oregon Fish & Wildlife SU, ONHP List 4, Cal Fish & Game SSC-HP, CFGC LE	Associated with dense riparian willow thickets. Documented during PacifiCorp's surveys in some of the more dense willow patches along Link River, at J.C. Boyle, Copco, and Iron Gate reservoirs, along the J.C. Boyle peaking reach, and along Klamath River from Iron Gate dam to Shasta River.
Purple martin *Progne subis*	FSC, Bureau of Land Management, Oregon Fish & Wildlife SC, ONHP List 2, Cal Fish & Game SSC-SP	Occurs in riparian and wetland forests, as well as mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper with sparse to moderate tree canopy closure. Nests in cavities and requires suitable nest sites located adjacent to open areas for foraging. Documented during PacifiCorp's surveys above the upper falls at Fall Creek.
Black-capped chickadee *Parus atricapillus*	Cal Fish & Game SSC-TP	Nests in a variety of woodland habitats wherever suitable, small nest cavities can be found. Documented during PacifiCorp's surveys along Link River and at Copco and Iron Gate reservoirs.

Species	Status[a]	Habitat and Location Where Found
Pygmy nuthatch *Sitta pygmaea*	Bureau of Land Management-T, Oregon Fish & Wildlife SV	Typically found in ponderosa pine forests with less than 70 percent canopy closure. Documented during PacifiCorp's surveys at Keno and J.C. Boyle reservoirs.
Western bluebird *Sialia mexicana*	Bureau of Land Management-T Oregon Fish & Wildlife SV, ONHP List 4	Found in a variety of open habitats; may be limited by the availability of suitable nesting cavities. Nests in open clearings adjacent to woodlands or in human-made structures providing suitable nest sites. Documented during PacifiCorp's surveys along Copco bypassed reach, along Fall Creek, and at Iron Gate reservoir.
Yellow warbler *Dendroica petechia*	Cal Fish & Game SSC-SP	Found in riparian deciduous forest, riparian shrub, scrub-shrub wetland, and forested wetland. Breeds in riparian habitat throughout North America and winters south from Mexico through South America. Documented during PacifiCorp's surveys throughout the project vicinity at all project reservoirs and in all project reaches. PacifiCorp assessed habitat suitability for the yellow warbler based on an existing HSI model and determined that the extremely dense tree and shrub habitat along Link River is most suitable while habitat along J.C. Boyle reservoir was least suitable. However, yellow warbler abundance was relatively high at both of these locations, even though the riparian zone at J.C. Boyle reservoir is generally lacking in hydrophytic shrubs.
Yellow-breasted chat *Icteria virens*	FSC, Bureau of Land Management-T, ONHP List 4, Cal Fish & Game SSC-SP	Found in the brushy understory of deciduous and mixed woodlands; breeds in brushy vegetation, typically willow thickets, along rivers and streams. Documented during PacifiCorp's surveys primarily in wetland and riparian habitats along J.C. Boyle peaking reach, at Copco reservoir, along Fall Creek, and along Klamath River from Iron Gate dam to Shasta River.
Mammals		
Yuma myotis *Myotis yumanensis*	FSC, Bureau of Land Management-T, ONHP List 4	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. Documented during PacifiCorp's surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse. Also known from J.C. Boyle peaking reach.
Townsend's big-eared bat *Corynorhinus townsendii townsendii*	FSC, Bureau of Land Management, Oregon Fish & Wildlife SC, ONHP List 2, Cal Fish & Game SSC-SP	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. Known from J.C. Boyle peaking reach but not documented during PacifiCorp's surveys.

Species	Status[a]	Habitat and Location Where Found
Western gray squirrel *Sciurus griseus*	Bureau of Land Management-T, Oregon Fish & Wildlife SU, ONHP List 4	Found in a variety of forested habitat types including mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak juniper with trees greater than 6 inches in diameter. Documented during PacifiCorp's surveys at J.C. Boyle and Copco reservoirs, along J.C. Boyle peaking reach, and along Copco bypassed reach.

[a] **FT =** Listed as threatened by the Fish and Wildlife Service.
FSC = Federal species of concern – candidate species the FWS is considering listing under the ESA.
CC = Birds of Conservation Concern (FWS Division of Migratory Bird Management)
S/M-C = Survey and Manage Species, as designated in the Northwest Forest Plan; category C – Uncommon, pre-disturbance surveys practical.
Bureau of Land Management = Bureau of Land Management sensitive species - species that could easily become endangered or extinct.
Bureau of Land Management-A = Bureau of Land Management assessment species - species not presently eligible for federal or state status that may need protection or mitigation.
Bureau of Land Management-T = Bureau of Land Management tracking species - more information needed to determine status.
OFWC LE = Listed as endangered by the Oregon Fish and Wildlife Commission under the OESA.
OFWC LT = Listed as threatened by the Oregon Fish and Wildlife Commission under the OESA.
Oregon Fish & Wildlife SC = Sensitive Critical - listing as threatened or endangered is pending, or listing as threatened or endangered may be appropriate if immediate conservation actions are not taken.
Oregon Fish & Wildlife SV = Sensitive Vulnerable - listing as threatened or endangered is not imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring. In some cases the populations are sustainable and protective measures are being implemented; in others, populations may be declining and improved protection measures are needed to maintain sustainable populations over time.
Oregon Fish & Wildlife SU = Sensitive Undetermined Status - species for which status is unclear.
ONHP List 1= threatened with extinction or presumed to be extinct throughout their entire range.
ONHP List 2 = threatened with extirpation or presumed to be extirpated from the state of Oregon.
ONHP List 4=of conservation concern but not currently threatened or endangered.
Cal Fish & Game SSC = Species of Special Concern - not listed under the federal or CA ESA but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence.
Cal Fish & Game SSC-HP = Species of Special Concern - High Priority - species that appear to have a high probability of extinction from their entire range in California.
Cal Fish & Game SSC-SP = Species of Special Concern – Second Priority - species that are definitely jeopardized and declining, but extinction or extirpation appears less imminent than species listed with a higher priority.
Cal Fish & Game SSC-TP = Species of special concern – Third Priority - species that do not appear to be facing extinction in the near future, but are declining seriously or are otherwise highly vulnerable because of human developments.
CFGC LE = Listed as endangered by the California Fish and Game Commission under the CESA.
CFGC LT = Listed as threatened by the California Fish and Game Commission under the CESA.

Wildlife Management in the Klamath Basin

The Klamath basin is an important wintering and staging area for waterfowl in the Pacific flyway (Oregon Fish & Wildlife, 1993). This area provides extensive feeding and resting areas for waterfowl during spring and fall migrations and is also an important nesting area. In the late 1800s, agriculture developers began diverting water from the basin for irrigation purposes and by the early 1900s, the federal government had developed an irrigation project in the basin. The federal government and the state of Oregon also began setting aside land in the basin in the early 1900s for the sole purpose of maintaining the values of the basin for waterfowl.

Lower Klamath National Wildlife Refuge. The Lower Klamath National Wildlife Refuge was established by President Theodore Roosevelt in 1908 as a waterfowl refuge and is now one of five national wildlife refuges in the Klamath basin (FWS, 2006a). The 49,600 acre refuge is located just east of U.S. Highway 97 along the Oregon-California border on both sides of Highway 161. The Lower

Klamath Refuge was established as the nation's first waterfowl refuge and is managed by the FWS to provide feeding, resting, nesting, and brood rearing habitat for waterfowl and other water birds. In addition to providing and enhancing habitat for fall and spring migrant waterfowl, the FWS objectives for this refuge include maintaining habitat for endangered, threatened, and sensitive species; protecting native habitats and wildlife that represent the natural biological diversity of the Klamath basin; integrating the maintenance of productive wetland habitats and sustainable agriculture; ensuring that the refuge agricultural practices conform to the principles of integrated pest management; and providing high quality wildlife-dependent visitor services.

Klamath Wildlife Area. The state of Oregon obtained the lands of the Klamath Wildlife Area in the early to mid 1900s to protect and enhance wildlife habitat for all endemic species, with an emphasis on ducks, geese, and other waterbirds (Oregon Fish & Wildlife, 1993). The Klamath Wildlife Area is comprised of four units: Shoalwater Bay and Squaw Point, located north of the Klamath Project vicinity along Upper Klamath Lake, and Miller Island and Gorr Island, located on the east side of the Keno reservoir. Oregon Fish & Wildlife management objectives for the Klamath Wildlife Area include providing waterfowl forage and loafing areas for over 4 million use days a year; providing habitat for feeding, resting, breeding, and rearing for the endemic birds, mammals, amphibians, and reptiles that use the Klamath Wildlife Area; protecting and maintaining threatened and endangered species that inhabit the area consistent with federal and state laws; providing opportunities for recreational harvest of waterfowl, upland game, and furbearers; and providing opportunities for wildlife viewing, public awareness, and other non-consumptive wildlife-oriented recreation.

3.3.4.2 Environmental Effects

3.3.4.2.1 Vegetation Management/Noxious and Invasive Species Control

Project operations have the potential to affect vegetation within and along the perimeter of project facilities, on project transmission line rights-of-way, and along project roads. Vegetation maintenance, including pesticide and herbicide use, and vegetation removal could directly affect plants in the project boundary, whereas project recreation could have indirect effects. Additionally, reservoir water-level fluctuations, water releases, and altered hydrology in project reaches could cause conditions that are favorable for the proliferation of noxious species.

PacifiCorp proposes to develop and implement a vegetation resources management plan in consultation with the resource agencies to guide land management practices on PacifiCorp-owned non-aquatic land within the project boundary. Specifically, this plan would address (1) project facility vegetation management; (2) noxious weed control; (3) vegetative restoration of sites that have been disturbed by project activities; (4) threatened, endangered, and sensitive plant protection; and (5) long-term monitoring. Additionally, PacifiCorp proposes, as part of its recreation resources management plan, to add native vegetation for use as screening at selected recreation sites. In addition to its proposed vegetation resources management plan, PacifiCorp proposes to coordinate with its transmission and delivery group to provide avoidance training, procedures, and scheduling to avoid or protect threatened, endangered, and sensitive plants in or near transmission line rights-of-way. PacifiCorp also proposes to enhance upland habitat for winter use by deer by managing approximately 1,031 acres of PacifiCorp-owned land within the project boundary to increase forage and cover habitat for deer. The upland habitat that PacifiCorp proposes to enhance occurs mostly around Iron Gate reservoir but also in smaller amounts near J.C. Boyle reservoir, along Fall Creek, and near Copco No. 2 reservoir. PacifiCorp proposes to work with resource agencies to investigate and implement habitat enhancements within the project boundary aimed at improving shrub forage in oak woodlands and chaparral habitats, and to reduce or eliminate livestock grazing effects.

Interior recommends that PacifiCorp develop, in consultation with the Bureau of Land Management, and submit to the Commission for approval, a plan for managing upland vegetation to

improve forest health (by reducing risk of insect infestation) and reduce potential fire hazard (by reducing wildfire risk) adjacent to project facilities. Interior recommends that the plan include provisions for (1) fuel reduction treatments; (2) thinning to reduce overstocking; (3) using a variety of fuel treatments including manual and mechanical treatment and prescribed fire; (4) thinning understory trees and ground vegetation to relieve stress on larger, older trees; (5) removing excess fuels through salvaging; (6) reestablishing conifer forest and woodland stands following stand-replacing events; and (7) implementing an underburn program following initial treatment. Interior also recommends that, within 1 year of license issuance, PacifiCorp consult with affected tribes to develop and implement a vegetation management plan to reestablish native vegetation and plants that are suitable to tribal members for food, medicine, basket material, cradles, art, and other cultural products.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp consult with it and other state, federal, and tribal agencies to develop a vegetation and noxious weed resource management plan and submit it to the Commission for approval. Oregon Fish & Wildlife recommends that the plan be updated every 5 years in consultation with the agencies to reflect new information, new management needs, and updated implementation strategies. In addition, Oregon Fish & Wildlife recommends that PacifiCorp prepare its vegetation and noxious weed resource management plan in consultation with Oregon Fish & Wildlife and other state, federal, and tribal stakeholders, and allow a minimum of 60 days for these entities to comment and make recommendations prior to PacifiCorp filing the plan with the Commission for approval. Oregon Fish & Wildlife recommends that PacifiCorp submit an annual report of activities completed the previous year as part of the vegetation and noxious weed resource management plan, along with an annual work plan to the Commission, Oregon Fish & Wildlife, and other state and federal agencies and tribes. Oregon Fish & Wildlife recommends that PacifiCorp include a monitoring and compliance report in its annual report including a narrative and compilation of information, data, and graphs summarizing progress toward implementation of strategies for managing native vegetation to optimize habitat for wildlife species and control invasive weeds.

Oregon Fish & Wildlife recommends that PacifiCorp develop, within 2 years of license issuance, a vegetation management plan in consultation with resource agencies including it, Cal Fish & Game, Bureau of Land Management, and FWS, which would include strategies for managing native vegetation to optimize habitat for wildlife species and control invasive weed species. Oregon Fish & Wildlife recommends that the plan guide land management practices on PacifiCorp-owned land, such as the management of forest, shrub, and grassland communities to contain, control, and suppress exotic and invasive weeds so they do not act as a source of infestations downstream or on adjacent property. Oregon Fish & Wildlife recommends that PacifiCorp improve winter range habitat for deer and elk on existing PacifiCorp lands and on Bureau of Land Management-administered lands in the Klamath River Canyon and acquire additional winter range habitat. Oregon Fish & Wildlife suggests vegetation treatments such as juniper removal, conifer and oak thinning, prescribed fire, mechanical shrub rejuvenation, improved livestock grazing management, and noxious weed control in mixed conifer, oak woodland, and shrub communities to improve the mosaic of forage and cover components. Oregon Fish & Wildlife also recommends that PacifiCorp prepare a plan for actively managing habitat for optimum big game benefits.

The Hoopa Valley Tribe recommendations pertaining to vegetation management are essentially identical to the two recommendations by Oregon Fish & Wildlife described above. However, the Hoopa Valley Tribe recommends that PacifiCorp include the Tribe in its consultations during preparation of these plans.

In its May 12, 2006, response to Oregon Fish & Wildlife's recommendation, PacifiCorp proposes allocating 2 years to develop the vegetation and noxious weed resource management plan to allow time for coordination among plans and among agencies. In its response to the Hoopa Valley Tribe, PacifiCorp states that it would consult with the appropriate agencies on specific environmental measures once a final license is issued by the Commission and accepted by PacifiCorp.

The Bureau of Land Management specifies that PacifiCorp develop, in consultation with the Bureau, and file for Commission approval, within 1 year of license issuance, a vegetation resources management plan that includes provisions for managing noxious and invasive plants and threatened, endangered, and sensitive plants on Bureau-administered lands that are affected by the Klamath Hydroelectric Project. The Bureau specifies that the section of the plan that addresses noxious and invasive plants include (1) a protocol for conducting weed surveys, including a review of federal, state, and local noxious weed lists, and the list of Exotic Pest Plants of Greatest Ecological Concern in California from the California Invasive Plant Council; (2) a timeline for a systematic survey of land affected by the project, including Bureau-administered lands within the project area; (3) a protocol for producing a geospatial map (e.g., GIS map) and digital database to store information on species occurrence, distribution, status according to the Oregon Department of Agriculture system of ranking species for control, and timing of last survey (PacifiCorp would make the database available to the Bureau); and (4) proposed treatments, mitigations, and best management practices for managing weeds on Bureau-administered lands that are affected by project maintenance, operation, and use. The Bureau specifies that the section of the plan that addresses threatened, endangered, and sensitive plant species include (1) a protocol for surveying Bureau-administered lands affected by the project consistent with accepted protocols to determine or verify the distribution of threatened, endangered, and sensitive plant species; (2) a protocol for documenting, protecting, and mitigating for effects on threatened, endangered, and sensitive plant species, including review of Bureau special status species and Oregon Natural Heritage Information Center, California Natural Diversity Database, and California Native Plant Society records; and (3) a protocol for surveying adjacent to project roads that cross seasonally wet meadows for occurrence of threatened, endangered, and sensitive plant species. The Bureau specifies that PacifiCorp implement the plan upon Commission approval, including any changes required by the Bureau.

On April 28, 2006, PacifiCorp proposed an alternative condition to the Bureau of Land Management's preliminary section 4(e) condition no. 7. In its alternative condition, PacifiCorp proposes limiting the scope of the vegetation resources management plan to Bureau of Land Management reservation lands within the project boundary and along roads for which PacifiCorp has sole or joint responsibility (as determined by the Commission), deleting references to "invasive plants," and modifying the plan to include provisions for periodic follow-up noxious weed surveys, rather than the "timeline for systematic survey of land affected by the project" as specified by the Bureau of Land Management. PacifiCorp also removes the Bureau's right to require changes to the vegetation management plan after it has been submitted to the Commission for approval.

In its May 12, 2006, response to the Bureau of Land Management vegetation management condition, PacifiCorp proposes to complete the vegetation resources management plan within 2 years, rather than 1 year, of license issuance. PacifiCorp points out that it may need 2 years to coordinate development of the plan with other resource management plans, to coordinate with other adjacent landowner activities related to cooperative weed management, and to coordinate with the Bureau of Land Management. PacifiCorp disagrees with the scope of the area addressed in the vegetation resources management plan specified by the Bureau of Land Management and suggests limiting the scope of the plan to Bureau reservation lands needed for project operations, including areas surrounding project facilities, project-related transmission lines, and project roads for which PacifiCorp has sole or joint responsibility (as determined by the Commission), as well as areas within the project boundary. PacifiCorp does not believe that a new systematic weed survey is needed. PacifiCorp proposes to use the existing weed inventory data as a baseline for identifying target species and management areas, conduct periodic follow-up project weed inventories, and coordinate regularly with resource agencies cooperatively involved in noxious weed control efforts through county-based cooperative weed management programs. PacifiCorp points out that, as a cooperator, it would be responsible for focusing the appropriate level of effort within the project boundary and attempting to manage weeds comprehensively in tandem with other cooperators.

In its response to comments, PacifiCorp disagrees with the Bureau of Land Management's contention that its surveys for threatened, endangered, and sensitive plants were inadequate and additional surveys are needed. PacifiCorp states that its surveys used stakeholder-approved methods, and focused on areas with a high probability of supporting targeted threatened, endangered, and sensitive plant species that were in areas associated with project facilities or affected by project operations. PacifiCorp asserts that it conducted reasonable surveys in areas affected by project operations and that it has adequate information to protect threatened and endangered species plants within the project boundary. PacifiCorp states that it would continue to share sensitive species information with the Bureau and if new populations of threatened, endangered, or sensitive plants are found within the project boundary, it would protect them through its vegetation management plan.

On January 24, 2007, the Bureau of Land Management slightly modified its section 4(e) condition no. 7, removing references to both invasive species and the Bureau's right to require changes to the vegetation resources management plan after it has been submitted to the Commission for approval. PacifiCorp had proposed both of these modifications in its alternative condition. In its modified condition, the Bureau of Land Management also specifies including rehabilitation measures and a subsequent monitoring program for the eroded area below the J.C. Boyle emergency spillway in the vegetation resources management plan.

In its comments on the draft EIS, the city of Yreka requests that the recommended vegetation resources management plan include provisions not to add any deciduous vegetation upstream of the city's municipal water supply intakes. The city points out that the intake screens already require regular clearing and if any deciduous vegetation is planted it could increase the city's maintenance costs at the intakes and fish screens. To avoid this potential problem, the city suggests using coniferous vegetation for visual screening.

Our Analysis

Vegetation management encompasses a wide variety of activities, such as roadside mowing, weed control, revegetation of eroding soils, and fire suppression. Vegetation management can have adverse or beneficial effects, or both, on natural resources, cultural values, recreation, aesthetics, health and safety, and socioeconomics. Field surveys have identified numerous sensitive plant populations throughout the project area. In addition, numerous populations of noxious and invasive plants have been documented. For this reason, consultation with the resource agencies, including the Bureau of Land Management, FWS, Oregon Fish & Wildlife, Cal Fish & Game, and tribal representatives, as appropriate, to develop and implement a comprehensive vegetation management plan that would include measures to enhance and protect rare plants, wetlands, riparian communities, and sensitive wildlife habitats is reasonable. However, it is appropriate for PacifiCorp to be responsible only for aspects of vegetation management that have a nexus to the project, which would generally include lands within the project boundary and access roads for which PacifiCorp has shared or sole responsibility for maintaining because they are needed for project purposes. Oregon Fish & Wildlife and the Hoopa Valley Tribe recommend PacifiCorp prepare a vegetation and noxious weed resource management plan within 1 year of license issuance and a vegetation management plan within 2 years of license issuance. We are not convinced that there is sufficient difference between these two plans to warrant preparation of two separate plans at 1-year intervals. It would be more efficient for all parties involved in developing, reviewing, and approving a vegetation management plan to develop a single, comprehensive plan for the entire project. Allowing 2 years for plan development and consultation prior to filing the plan with the Commission for approval would enable the many aspects associated with vegetation management in the broad geographical expanse of the project to be addressed thoroughly.

In the following section, we address development of a vegetation management plan, and focus on four aspects of vegetation management related to terrestrial resources: protection of special status plants, control of noxious weeds and invasive species, management of upland vegetation to improve forest, and

enhancement of ethnobotanical resources. We address the use of vegetation for screening purposes in section 3.3.7, *Land Use and Aesthetic Resources*.

Protection of Special Status Plant Species. PacifiCorp documented 67 occurrences of 12 plant species with special status in the project vicinity either during its 2002 surveys or previously by the Bureau of Land Management, Oregon Natural Heritage Program, or the California Natural Diversity database. In its March 27, 2006, letter to the Commission, Interior points out that, subsequent to PacifiCorp's 2002 surveys, the Bureau of Land Management found bristly sedge (*Carex comosa*) along the J.C. Boyle reservoir and at the Topsy Campground. Bristly sedge is considered an assessment species by the Bureau of Land Management, which means that it is not presently eligible for official federal or state status but is of concern in Oregon and may, at a minimum, need protection; the Oregon Natural Heritage Information Center includes it on its List 2-ex (extirpated from the state of Oregon) and the California Native Plant Society also includes it on its List 2 (rare, threatened, or endangered in California, but more common elsewhere). The Bureau of Land Management specified that PacifiCorp survey Bureau of Land Management-administered lands affected by the project as well as adjacent to project roads that cross seasonally wet meadows for occurrence of threatened, endangered, and sensitive plant species. PacifiCorp proposes to monitor the locations of sensitive plant species it identified in its surveys and any additional populations of sensitive plant species documented in the project boundary. We see no reason to require PacifiCorp to conduct additional surveys for sensitive plant species, particularly since PacifiCorp proposes to monitor populations identified by others subsequent to its surveys, and additional surveys would not likely provide additional information.

A few special status species could potentially be threatened by noxious and invasive plant populations that are in proximity and share the same habitat, such as Greene's mariposa lily and Bolander's sunflower which were found in association with yellow starthistle and annual bromes. Because all of these special status plant species could be affected by the spread of noxious and invasive plant species or a variety of vegetation management activities (e.g., brushing, mowing, herbicide application, replanting projects), recreation-related activities (e.g., camping, wood-cutting, OHV use), and other ground disturbances, we conclude that consultation with the Bureau of Land Management, FWS, Oregon Department of Agriculture, Oregon Natural Heritage Program, Cal Fish & Game, and California Native Plant Society to aid in the identification and development of any measures that may be needed to protect these species is appropriate.

Control of Noxious Weeds and Invasive Plants. Noxious weeds are a growing threat to the environment of Oregon and California because of their potential to degrade native plant communities, outcompete rare species, and reduce wildlife habitat values. Both federal and state laws require landowners to manage noxious weeds within their ownerships. PacifiCorp determined that 21 noxious weeds and invasive plant species occur in the vicinity of the Klamath Hydroelectric Project. Currently, the species of greatest concern at the project is yellow starthistle, identified by Oregon Department of Agriculture with both a B designation, which is a noxious weed of economic importance, and a T designation, which is a priority noxious weed designated by the State Weed Board as a weed species targeted for biological control. Yellow starthistle is also identified by CalEPPC as a Class A-1 species, which is a widespread invasive wildland pest, and identified by California Department of Food and Agriculture as a Class C weed, which is not subject to any state enforced action outside of nurseries except to retard spread. An additional 18 species are identified by Oregon Department of Agriculture with B designations; 5 of these are also identified by CalEPPC as Class A-1 species and another 3 species are identified by California Department of Food and Agriculture as Class A weeds, which are subject to state enforced action such as eradication, quarantine, containment, rejection, or other holding action.

Successful weed control requires a cooperative effort by all landowners and land managers in the vicinity, because untreated weeds on adjacent lands provide a ready seed source for infestation by new species and re-infestation after treatment of existing problem weeds. Developing an noxious weed and invasive plant management plan in consultation with the Bureau of Land Management, FWS, Oregon

Fish & Wildlife, Oregon Department of Agriculture, Cal Fish & Game, California Department of Food and Agriculture, Klamath County, Siskiyou County, the tribes, and local landowners as part of the vegetation management plan would facilitate an integrated approach to control effects, and is appropriate for all project lands. Implementation of weed control measures on adjacent non-project lands would help reduce the risk of spread of weed infestations. We agree that weed management on lands affected by project operations is necessary to control the spread of noxious weeds and invasive plants. Eradication may be attainable for species that are currently limited in distribution, but attempts to eradicate species that are already well-established and widespread, such as yellow starthistle, would not be likely to succeed, except at an unacceptably high cost to other resource values.

Noxious weeds and invasive plants can interfere or degrade ecological function of native species or impair recreational experiences. As such, noxious weed and invasive plant monitoring should be included as an element within other plans that could entail monitoring for erosion, such as the recreational resource management plan (discussed in section 3.3.6, *Recreational Resources*), the project roadway management plan (discussed in section 3.3.7, *Land Use and Aesthetic Resources*), and the historic properties management plan (discussed in section 3.3.9, *Cultural Resources*).

Management of Upland Vegetation to Improve Forest Health. Years of fire suppression have allowed the accumulation of fuels over large portions of California and Oregon's forest and range habitat, on both public and private lands. Accumulation of fuels increases the risk of devastating wildfire. In some stands, fire suppression results in a dense understory that prevents sunlight from reaching the forest floor, reducing the abundance of annual herbaceous cover that would provide forage for deer and other wildlife species. On shrub-dominated sites, old shrubs may become woody, less palatable, and less nutritious as browse for wildlife.

The deer and elk populations in the project vicinity, which is located within the Keno Wildlife Management Unit in Oregon and the Cascade-North Sierra Nevada Deer Assessment Unit in California, are affected by elevation that influences snowfall in the winter and the pattern of forage and cover habitats throughout the area. The long-term changes in management of forests and shrublands that occurred in the project vicinity since the early 1900s have caused a decline in the disturbances that perpetuate early-successional habitats, which provide important deer habitat. Since the 1960s, a combination of intensive timber harvest and fire suppression (or in some cases inappropriate timing of prescribed fire) has brought about more forage-limited, second-growth forests and more decadent shrublands that have unavailable or low quality browse and little herbaceous vegetation. Forage condition on winter range is also declining because of infestations of exotic weeds.

Prescribed fire, as recommended by Interior and Oregon Fish & Wildlife, could increase soil fertility, promote plant vigor by removing old shoots and foliage, and enhance herbivorous wildlife food sources by increasing the palatability and protein content of resprouting shrubs. A controlled fire component of a vegetation management plan for land within the project boundary could reduce the danger of wildfires and improve the quality of the deer and elk winter range. Implementation of prescribed fire may benefit several species associated with young forested stands, including deer and black bear. It would also help to protect habitat over the long-term for several species using mature forests in the project area, including pileated woodpeckers, hairy woodpeckers, and wood ducks. Similar actions on adjacent non-project lands also would benefit a variety of wildlife species.

Selectively removing or thinning overstory vegetation could also be used to create small openings and thus improve forage quality and quantity. In addition, these small openings could either be seeded with forage species or planted with forage species seedlings to improve forage conditions for big game such as deer and elk. Using native species for seeding or seedlings can be particularly productive and also offers an opportunity to reduce weed infestation.

Maintaining or increasing areas of late successional forest especially with multi-canopy stands also would benefit deer and elk by limiting the amount of snow on the ground during the winter months.

Creating and protecting habitat for species that use cavities and snags, such as woodpeckers and small mammals, would enhance reproduction and foraging opportunities.

The city of Yreka recommends using coniferous vegetation for visual screening. Planting coniferous shrubs and trees to provide visual barriers along roads, rights-of-way, and other open areas also would provide wildlife cover, especially in the winter months when deciduous vegetation is bare.

Enhancement of Ethnobotanical Resources. Interior identified a number of plants that grow in the project area, such as redbud and willow, as being of special importance for food, medicine, basket materials, art, and cultural use. Incorporating plants of ethnobotanical importance into revegetation projects that would be implemented during the new license period, such as stabilization of spoil piles, road improvements, and vegetative screening at recreational sites, would enhance ethnobotanical resources, provided PacifiCorp schedules time to investigate sources of native plant materials and the possibility of contract growing well in advance of the dates the plants are needed.

Riparian and Wetland Habitat Connectivity

There are about 244 acres of wetland and riparian vegetation types in the proposed project boundary. The distribution of riparian and wetland habitats at the Klamath Hydroelectric Project is important for a wide variety of wildlife species. Habitat conditions vary along the shorelines of the project reservoirs and river reaches, with a patchy distribution of riparian species and invasive species outcompeting native vegetation in some locations. Several factors could potentially affect and influence riparian and wetland vegetation along the shorelines of project reservoirs and river reaches; project-related factors include recreational activities, reservoir fluctuation regimes, and minimum flow releases.

The ongoing operation of the J.C. Boyle, Copco No. 1 and No. 2, and Iron Gate developments would affect the reservoir fluctuation zone and the varial zone and shoreline vegetation along 11.5 miles of the J.C. Boyle peaking reach, 4.4 miles of the J.C. Boyle bypassed reach, and 1.5 miles of the Copco No. 2 bypassed reach, as well as vegetation resources adjacent to project facilities and recreation sites. Regardless of the flow regime that may be specified in a new license, active management of riparian habitat may be necessary to notably improve conditions in the project area. Changes in vegetation at the upper and lower ends of the current varial zone may occur as plant communities adjust to the new peaking restrictions. Current operations also affect up to 58 acres of the varial zone in the J.C. Boyle peaking reach where daily fluctuations may be contributing to conditions favoring certain species, such as reed canarygrass. We describe proposed and recommended flow regimes in project reaches in detail in section 3.3.3.2.1, *Instream Flows*.

PacifiCorp recognizes that the closer that instream flows mimic the natural hydrograph (peaking in late winter or spring and then gradually declining), the more likely that conditions suitable for native plant seed dispersal, germination, and growth would be present along river systems. However, PacifiCorp states that it is beyond the capacity of the project to restore the natural hydrograph and also recognizes that ongoing private non-project land uses are expected to continue. Therefore, PacifiCorp proposes to protect existing riparian and wetland habitat within the project boundary, and, where necessary, to restore currently degraded riparian habitat along about 10 miles of reservoir and Klamath River shoreline.

Based on its consultation with resource agencies, PacifiCorp proposes to implement site-specific measures to rehabilitate and stabilize shorelines and overgrazed or otherwise damaged riparian sites within the project boundary. PacifiCorp proposes to focus much of this effort on portions of the J.C. Boyle reservoir where PacifiCorp owns land, the J.C. Boyle peaking reach, Fall Creek, and Iron Gate reservoir. PacifiCorp proposes restoration activities including small-scale, site-specific removal of unwanted plant species (reed canarygrass and blackberry), inter-planting of desirable species (willows, sedges, and rushes) to increase diversity, and controlling livestock access with additional fencing where necessary. PacifiCorp acknowledges that it would probably continue to use cattle production as a

property management tool on its lands within the project boundary, but states that its priority would be meeting habitat needs for wildlife and botanical resources.

Currently, between 19 and 30 percent of the J.C. Boyle, Copco, and Iron Gate reservoirs are bordered by riparian and wetland habitat. PacifiCorp proposes to protect and restore riparian habitat along the margin of the J.C. Boyle reservoir by developing shoreline trees and shrubs, protecting wetland sites from livestock or people, and developing a plan for protecting wetlands near recreational areas. PacifiCorp would also focus its habitat protection measures on the large and ecologically diverse wetland adjacent to Sportsman's Park along the shoreline of the J.C. Boyle reservoir. PacifiCorp proposes to protect the existing riparian areas located in the project boundary on the margins of the Copco and Copco No. 2 reservoirs. At the Iron Gate reservoir, PacifiCorp proposes to establish additional riparian vegetation to improve its distribution and increase the width of existing riparian vegetation by fencing or redirecting human use.

PacifiCorp also proposes to protect and restore riparian habitat along 5.3 miles of the Klamath River upstream of Copco reservoir and to protect the following tributary and river reaches: (1) 2.2 miles of Shovel Creek/Negro Creek; (2) 1.5 miles of Fall Creek; (3) 1 mile of Jenny Creek (PacifiCorp proposes a protection zone of 100 feet on each side of Jenny Creek because of its relatively well developed riparian forest habitat); (4) 0.9 mile of Long Gulch Creek; (5) 1.3 miles of Bogus Creek; and (6) 0.5 mile of the Klamath River downstream of Iron Gate dam. In addition, PacifiCorp proposes to create a setback and, if needed, an erosion control strip to protect the wetland located near Copco Village from road runoff.

FWS recommends that PacifiCorp consult with FWS, NMFS, the Bureau of Land Management, Oregon Fish &Wildlife, Cal Fish & Game, and the affected tribes within 1 year of license issuance to develop a riparian habitat management plan to conserve, develop, and enhance fish and wildlife resources and file it with the Commission for approval. FWS recommends that the plan identify actions to minimize the effects of project operations on riparian habitats and identify site-specific restoration measures for riparian habitat affected by the project. The recommended riparian habitat management plan would include the following objectives for Bureau of Land Management-administered lands: (1) mitigate effects of project facilities and/or operations by restoring degraded riparian habitats within all project reaches; (2) inventory riparian areas as needed to develop restoration goals based on riparian ecological type and potential condition; (3) identify activities necessary to restore hydrologic connectivity in the varial zone and diversity of riparian species; (4) coordinate riparian habitat restoration activities with other plans for aquatic habitat, streamflow, geomorphologic processes and features, wildlife habitat, and vegetation management, including treatment of noxious weeds; (5) monitor implementation of the riparian habitat management plan to determine whether planned actions are meeting license condition objectives, conform to accepted monitoring protocols, and meet reporting requirements; and (6) monitor effectiveness of riparian mitigation and restoration and apply adaptive management principles to ensure the plan objectives are accomplished. FWS recommends that PacifiCorp implement measures to (1) increase riparian habitat on the low terraces in the Oregon portion of the J.C. Boyle peaking reach; (2) improve riparian conditions in the J.C. Boyle peaking reach varial zone; (3) improve habitat conditions for threatened, endangered, and sensitive plant and animal species associated with riparian, wetland, or open water habitats; and (4) reduce conditions that that are conducive to the establishment of reed canarygrass, yellow starthistle, and other noxious weeds or invasive plant species.

In its response to FWS, in a letter filed with the Commission on May 12, 2006, PacifiCorp disagrees with FWS' assertion that reed canarygrass can be controlled in 2 or 3 years with continued monitoring and follow up treatments for another 5 to 10 years. PacifiCorp states that it would be extremely difficult, if not impossible, to eradicate reed canarygrass within the project boundary. It points out that it found reed canarygrass in river segments with stable flows as well as in the J.C. Boyle peaking reach and that long-term control would be extremely difficult given the extensive agricultural areas upstream of J.C. Boyle reservoir that would continue to be an abundant seed source. PacifiCorp states that large-scale control of reed canarygrass requires extensive efforts, and many methods described in the

literature cited by FWS may not be practical for implementation at the project, such as long-duration flooding to kill reed canarygrass, due to other upstream demands for the available water and the lack of water control structures to produce sustained flooding. PacifiCorp states that it would consider mechanical and chemical controls within the riparian zone but because there would always be a seed bank and an upstream seed source, it would need to repeat these methods every 3 to 4 years. PacifiCorp suggests focusing on sites with the best potential for establishing alternative native vegetation and areas that would benefit the most from restoration.

Siskiyou County recommends that over the next 5 to 10 years PacifiCorp fund approximately $26 million worth of programs identified by the Shasta Valley and Siskiyou resource conservation districts including habitat improvement programs focused on minimizing the impacts on riparian areas, ensuring adequate flows, and addressing temperature related issues; water quality programs focused on implementing riparian plantings projects to increase shade needed to cool water temperatures; and monitoring and assessment programs. Siskiyou County suggests that PacifiCorp should use the local knowledge, track record, and commitment of the resource conservation districts. In its comments on the draft EIS, Siskiyou County reduced its funding request to approximately $18 million.

Our Analysis

Several amphibian species as well as small mammals, aquatic furbearers, and some reptiles use riparian habitats for breeding, foraging, or cover. Several special status species and riparian focal species including the yellow warbler, song sparrow, willow flycatcher, blackcrowned night heron, yellow rail, western yellow-billed cuckoo, purple martin, yellowbreasted chat, Oregon spotted frog, and western toad use riparian habitats substantially more often than upland habitats. Floodplain woodlands support higher densities of breeding birds than upland woodland or herbaceous habitats. Although birds are highly mobile, there has been some documentation that riparian connectivity plays an important role especially during dispersal. Juvenile birds are often more dependent on continuous riparian habitat for dispersal than are adults of the same species.

Under the current flow regime, riparian vegetation is encroaching into the active stream channel onto formally active gravel bar, floodplain, and bank surfaces, particularly in the J.C. Boyle bypassed reach. The vegetated banks, which include some of the stream channel, are typically wider with riparian grass covering a large area. Most of this riparian grass is reed canarygrass. PacifiCorp proposes to release an additional 100 cfs either into the J.C. Boyle peaking reach (over the existing minimum flow released at J.C. Boyle dam and spring accretion that occurs in the bypassed reach) or at the J.C. Boyle powerhouse as well as reducing the ramping rates in the peaking reach, which may slightly reduce the competitive advantage that reed canarygrass has in the upper portion of the varial zone, and therefore, may enhance conditions for native vegetation.

Proposed flows would increase water velocities somewhat, decrease sediment deposition, and help reduce further encroachment of vegetation in the stream channel while promoting the establishment of beneficial vegetation on gravel bars, floodplains, and terraces. The amount of vegetation that would become established would likely vary from site to site along the affected stream reaches, depending on factors such as aspect, slope, width of the floodplain, substrate, stream gradient, and existing plant community, in addition to flow volumes. Higher stem densities may reduce water velocities along the edges of the channel, allowing increased sediment deposition and further encroachment of native vegetation. The peaking reach flow regimes recommended by others would substantially increase minimum flows, reduce ramping rates, or require run-of-river operations. Daily fluctuations of water levels would be eliminated, which could result in a more stable riparian environment. This could result in more favorable conditions for re-establishment of native riparian vegetation and a reduction in the competitive reed canarygrass, which are adapted to harsh conditions (The Nature Conservancy, 2004). However, it is extremely difficult to predict how the altered flows would affect the already established reed canarygrass or new willow establishment. Monitoring of invasive plant species following

implementation of the flow regime specified in a new license would facilitate development of adaptive management measures that are tailored to the response of the affected populations.

The proposed flows would not likely enhance coyote willow reproduction and distribution in the J.C. Boyle peaking reach because they do not include peak (flood) flows that would disturb and create fresh, bare surface; declining spring and summer flows that would be timed coincident with seed dispersal; and declining flows during the growing season to allow coyote willow an opportunity to establish. As described in section 3.3.1.2.5, *Fluvial Geomorphic Effects on Riparian Vegetation*, spring peak flows (those able to scour soil surfaces) and the descending limb of the annual hydrograph relative to seed dispersal are the most important aspects for riparian establishment. As described above, flows recommended by others would eliminate daily fluctuations of water levels, but would not provide the degree of seasonal variability that would be associated with an unregulated river, because flows through the project would still be governed by the requirements of the BiOp for coho salmon that requires Reclamation to release specified flows to the project for release by PacifiCorp at Iron Gate dam. Consequently, it is difficult to predict how the flows recommended by others would affect new willow establishment. We consider the most efficient way to increase the rate of expansion and abundance of willow in most reaches and reservoirs would be to actively implement willow restoration measures, including planting willow and excluding herbivores. PacifiCorp proposes to protect and restore riparian habitat along the margin of the J.C. Boyle reservoir, Copco and Copco No. 2 reservoirs, and Iron Gate reservoir. Establishing additional riparian vegetation would likely enhance habitat for riparian wildlife, and fencing or redirecting human use would increase the width of existing riparian vegetation by protecting wetland sites from encroachment from livestock or people. PacifiCorp may plant coyote willow as part of its site restoration activities. If that is the case, once it is established, coyote willow is likely to maintain its presence in the reach by clonal growth in many instances and potentially would serve as important habitat for fish and wildlife.

PacifiCorp also proposes to protect and restore riparian habitat along about 5.3 miles of the peaking reach of the Klamath River upstream of Copco reservoir as well as 7.4 miles of tributary and river reaches including 2.2 miles of Shovel and Negro creeks. Protection and restoration of these areas is appropriate because of the presence of sensitive species along some of these reaches and extensive grazing in the project vicinity. Protection measures, such as exclusion fencing, would protect sensitive species and increase habitat connectivity between mainstem and tributary riparian habitat. Protection of riparian vegetation along Shovel and Negro creeks, which are the primary spawning streams for rainbow trout in the peaking reach, would retain shade and prevent excessive warming of water during the summer and serve as cover for trout fry that likely remain in these tributaries for much of the summer.

Wetlands provide habitat for numerous plant and wildlife species, collect and hold water, buffer the effects of floods, and conserve moisture for drier seasons of the year. Currently, wetland habitat along the project reservoirs is limited mostly to small patches in protected locations and near inlets/tributaries. PacifiCorp's proposal to protect wetlands near recreational areas, including the large and ecologically diverse wetland adjacent to Sportsman's Park along the shoreline of J.C. Boyle reservoir and the wetland located near Copco Village, also would benefit those species of fish and wildlife that use wetland habitats.

FWS recommends that PacifiCorp develop a riparian habitat management plan to conserve, develop, and enhance fish and wildlife resources. PacifiCorp has proposed including riparian enhancement measures in its wildlife habitat management plan, and details of the elements of the plan would be addressed during consultation with the resource agencies. PacifiCorp's approach would enable riparian habitat management measures to be addressed in an efficient manner that would achieve the same objectives specified by FWS without the need to develop a separate plan. Cross-referencing vegetation management aspects to a vegetation management plan would ensure that the vegetative aspects of riparian habitat management are integrated with the wildlife habitat management aspects.

Siskiyou County recommends that over the next 5 to 10 years PacifiCorp fund approximately $26 million worth of programs identified by the Shasta Valley and Siskiyou resource conservation districts. Although we recognize that these resource conservation districts may have local knowledge and expertise, Siskiyou County has not identified specific measures that would be implemented with these funds, and thus we cannot assess the benefits of such programs. The Commission must establish a connection of environmental measures that it includes in a new license to project purposes and there is no basis for us to make this connection with the information provided by Siskiyou County.

3.3.4.2.2 Wildlife Resource Management

PacifiCorp proposes to develop and implement a wildlife habitat management plan that would describe all wildlife enhancement measures and provide a mechanism for coordinating with the PacifiCorp environmental management system and best management practices and for protecting and monitoring threatened, endangered, and sensitive species. PacifiCorp proposes to include the following key components in its wildlife habitat management plan: (1) restore riparian habitat along river and reservoir shorelines to improve habitat structure and connectivity; (2) install wildlife crossing structures on the J.C. Boyle canal to enhance connectivity; (3) manage habitats within the project boundary for deer winter range objectives; (4) monitor transmission lines and retrofit poles on lines where birds have died to improve avian protection; (5) develop amphibian breeding habitat along Iron Gate reservoir; (6) fund annual aerial bald eagle surveys to document new nests and productivity of territories, and protect bald eagle and osprey habitat within the project boundary; (7) selectively close roads that are unnecessary for project operation or other management activities; (8) install turtle basking structures in selected sites; (9) install bat roosting structures near project sites known to support roosting bats; (10) conduct surveys for threatened, endangered, and sensitive species in areas to be affected by new recreation development; and (11) monitor effectiveness of enhancement measures over the course of the new license.

Oregon Fish & Wildlife recommends that, within 1 year of license issuance, PacifiCorp consult with it and other state, federal, and tribal agencies to develop a wildlife mitigation resource management plan and a fish and wildlife habitat restoration resource management plan and submit them to the Commission for approval. Oregon Fish & Wildlife recommends that both of these plans be updated every 5 years in consultation with the agencies to reflect new information, new management needs, and updated implementation strategies. Oregon Fish & Wildlife also recommends that PacifiCorp prepare its wildlife mitigation resource management plan and fish and wildlife habitat restoration resource management plan in consultation with it and other state, federal, and tribal stakeholders, and allow a minimum of 60 days for these entities to comment and make recommendations prior to PacifiCorp filing the plans with the Commission for approval. In addition, Oregon Fish & Wildlife recommends that PacifiCorp submit annual reports of activities completed the previous year as part of these two plans, along with an annual work plan, to the Commission, Oregon Fish & Wildlife, and other state and federal agencies and tribes.

Oregon Fish & Wildlife recommends that PacifiCorp address monitoring and compliance in its annual report on the wildlife mitigation resource management plan. It recommends a narrative and graphs summarizing an annual compilation of information and data on wildlife environmental measures including (1) monitoring for raptor injury and mortality at power poles and implementing protective measures, as appropriate; and (2) monitoring for wildlife entrapment and mortality at power canals and other project features and implementing protective measures, as appropriate. Oregon Fish & Wildlife also recommends a monitoring and compliance report in PacifiCorp's annual report on the fish and wildlife habitat enhancement resource management plan with a narrative and compilation of information summarizing progress toward restoring fish and wildlife habitat within, below, and above the project. Cal Fish & Game and the Hoopa Valley Tribe recommendations are nearly identical.

In its May 12, 2006, response to Oregon Fish & Wildlife's and Cal Fish & Game's recommendations, PacifiCorp proposes allocating 2 years to develop the wildlife mitigation resource management plan and the fish and wildlife habitat restoration resource management plan to allow time for

coordinating among plans and among agencies. PacifiCorp also states that it should not be required to mitigate for habitat inundated by the construction of the Klamath Hydroelectric Project because this effect was pre-project.

Oregon Fish & Wildlife recommends that PacifiCorp develop, within 2 years of license issuance, a comprehensive wildlife mitigation plan in consultation with it and affected resource agencies, which would include routine monitoring and evaluation of wildlife and their habitats associated with the project and a long-term plan for implementation and monitoring consistent with federal, state, local, and tribal wildlife management objectives. Oregon Fish & Wildlife recommends that the wildlife mitigation plan compensate in-kind, to the extent feasible, for project development and ongoing effects of project operations and facilities such as riverine and reservoir fluctuations, habitat loss, habitat degradation, and hazards from power canals, power poles, and transmission lines. Oregon Fish & Wildlife further recommends that any new project development or effects authorized by project relicensing be consistent with its Fish and Wildlife Habitat Mitigation Policy and applicable wildlife management policies such as the Wildlife Diversity Plan and the Comprehensive Wildlife Conservation Strategy. Cal Fish & Game makes a similar recommendation.

Oregon Fish & Wildlife recommends that PacifiCorp develop, within 1 year of license issuance, a fish and wildlife habitat enhancement plan in consultation with it, the Bureau of Land Management, Cal Fish & Game, FWS, and NMFS to develop strategies to implement mitigation measures for ongoing project-related effects on fish and wildlife populations. Oregon Fish & Wildlife recommends that the plan identify strategies for enhancing and improving wetlands, riparian and riverine habitats, and riparian, aquatic, and terrestrial species connectivity in mainstem reaches and tributaries containing native fish and wildlife species that may be affected by the continued operation of the project; it recommends that PacifiCorp fund implementation of these strategies.

This recommended plan would focus on restoring riparian areas, wetlands, instream flow, and water quality, and acquiring land in appropriate reaches within and above the project. Oregon Fish & Wildlife recommends that the plan include procedures based on common methods used in wildlife science, including state of the art techniques for prioritizing and selecting habitat restoration, conservation, and/or acquisition projects. In addition, Oregon Fish & Wildlife recommends that PacifiCorp establish a habitat fund to conduct restoration, conservation, and/or acquisition projects as described in the annual work plan for its habitat enhancement program; the amount of the fund would be determined in consultation with it, the Bureau of Land Management, and other fish and wildlife agencies, and would be adjusted annually based on the consumer price index. PacifiCorp would annually deposit the designated amount into the fund beginning the second year after license issuance on the submittal date of the annual report of activities completed the previous year as part of the fish and wildlife habitat enhancement plan. Operation and maintenance costs associated with habitat enhancement also would be covered by this fund. The Hoopa Valley Tribe makes a similar recommendation.

If unanticipated circumstances or emergency situations arise in which wildlife species not listed as threatened or endangered by FWS are being killed, harmed or endangered by any of the project facilities or as a result of project operations, Oregon Fish & Wildlife recommends that PacifiCorp immediately take appropriate action to prevent further loss in a manner that does not pose a risk to human life, limb, or property. Within 48 hours of such an occurrence, PacifiCorp would notify Oregon Fish & Wildlife's nearest office as well as the nearest offices of NMFS, FWS, Bureau of Land Management, Cal Fish & Game, Water Board, Oregon Environmental Quality, and Oregon Water Resources Department, as appropriate, and would comply with any restorative measures required by the resource agencies to the extent such measures do not conflict with the conditions of its license. PacifiCorp would notify the Commission as soon as possible but no later than 10 days after each occurrence and inform the Commission as to the nature of the occurrence and restorative measures taken.

The Bureau of Land Management specifies that PacifiCorp develop, in consultation with the Bureau, and file for Commission approval, within 2 years of license issuance, a wildlife habitat management plan for Bureau-administered land affected by project operations and maintenance. The Bureau specifies that the plan include measures for (1) wildlife crossings and escape ramps for the J.C. Boyle canal and effectiveness monitoring; (2) western pond turtle habitat enhancements and effectiveness monitoring; and (3) threatened, endangered, sensitive, and special status species surveys and monitoring including (a) survey protocols for long-term surveys and monitoring of threatened, endangered, and sensitive species and their habitat for Bureau-administered lands within the project boundary to assess effects and develop necessary protective measures; (b) identification of restoration, protection, and/or enhancement measures for threatened, endangered, or sensitive species; and (c) seasonal restrictions for active nest sites on Bureau-administered lands for bald eagles, golden eagles, ospreys, peregrine falcons, and other raptors affected by project operations. The Bureau specifies that PacifiCorp implement the plan upon Commission approval, including any changes required by the Bureau.

PacifiCorp proposed an alternative condition to the Bureau of Land Management's preliminary section 4(e) condition no. 8 by letter dated April 28, 2006. In its alternative condition, PacifiCorp proposes to limit the scope of the wildlife habitat management plan to Bureau of Land Management reservation lands within the project boundary, suggests that, instead of monitoring the effectiveness of the wildlife crossings and escape ramps for the J.C. Boyle canal, it would monitor use instead, and suggests that monitoring of escape ramps would be limited to existing escape ramps. PacifiCorp also suggests that, instead of monitoring the effectiveness of western pond turtle basking structures, it would monitor use instead. PacifiCorp also removes the Bureau of Land Management's right to require changes to the wildlife habitat management plan after it has been submitted to the Commission for approval.

In its May 12, 2006, response to agency terms and conditions, PacifiCorp points out that there are few opportunities for adding wildlife crossings at sites where animals might benefit from such enhancements and states that it would work with the Bureau of Land Management to assess sites for wildlife crossings at feasible locations along the J.C. Boyle canal. PacifiCorp also states that additional wildlife escape ramps are not needed at the J.C. Boyle canal since it already has two wildlife escape ramps that have backwater eddies and gradual ramps that animals can use to escape the system. PacifiCorp believes that monitoring the effectiveness of wildlife crossings and escape ramps is not appropriate because there is no generally accepted criteria by which to judge effectiveness and suggests monitoring use instead. Similarly, PacifiCorp suggests that it would monitor observed use of western pond turtle basking structures and the availability of the structures to turtles at various springtime flows rather than their effectiveness, because there is no generally accepted criteria by which to judge effectiveness. PacifiCorp clarifies that it concluded that, based on occurrence and distribution in its study area, threatened, endangered, and sensitive species are tolerant of current conditions and, even though its proposed flows would slightly reduce the varial zone, its proposed enhancement measures would benefit riparian habitat. PacifiCorp also states that it does not believe that continuous protocol surveys and monitoring of threatened, endangered, and sensitive species and their habitat are needed to assess continuing effects of routine operation and maintenance of the project. However, PacifiCorp states that it recognizes that new surveys may be needed when planning for new, non-routine activities on Bureau of Land Management lands within the Project boundary and proposes to consult with the Bureau of Land Management to determine the need for any new surveys. Finally, PacifiCorp suggests working with Interior to establish seasonal restriction guidelines to avoid disturbing certain wildlife species during critical breeding and young-rearing time periods and to apply those guidelines as appropriate.

On January 24, 2007, the Bureau of Land Management slightly modified its section 4(e) condition no. 8, removing references to both effectiveness monitoring and the Bureau's right to require changes to the wildlife habitat management plan after it has been submitted to the Commission for approval. PacifiCorp had proposed both of these modifications in its alternative condition. The Bureau of Land Management notes that monitoring use of wildlife crossings, escape ramps, and measures for

western pond turtle would determine whether the structures are effective or not, so it now specifies monitoring use of them.

Our Analysis

A comprehensive wildlife resources plan detailing the actual measures that PacifiCorp would implement that the appropriate resource agencies can review and comment on would provide an effective approach to managing wildlife species affected by project operations. At a minimum the plan should address all lands within the project boundary, not only those lands administered by the Bureau of Land Management. Oregon Fish & Wildlife, Cal Fish & Game, and the Hoopa Valley Tribe recommend PacifiCorp prepare a wildlife mitigation resource management plan within 1 year of license issuance. The Bureau of Land Management and Oregon Fish & Wildlife also respectively recommend that PacifiCorp prepare a wildlife habitat management plan and a wildlife mitigation plan within 2 years of license issuance. Oregon Fish & Wildlife and the Hoopa Valley Tribe also recommend that PacifiCorp prepare a fish and wildlife habitat restoration resource management plan within 1 year of license issuance.

We note that our baseline for potential action to be considered in a new license entails protection and enhancement measures, rather than mitigation for effects of initial project construction. We are not convinced that there is sufficient difference between these plans to warrant preparation of two separate sets of plans at 1-year intervals. It is more efficient for all parties involved in the development, review, and approval of protection and enhancement measures for wildlife to develop a single, comprehensive wildlife management plan for the entire project. Although measures that would protect or enhance aquatic habitat also could benefit from measures that pertain primarily to wildlife, it is more efficient to address aquatic management issues in a separate focused aquatic management plan. Allowing 2 years to consult with the agencies and prepare this plan is appropriate, considering the breadth of the measures. It would be beneficial to have a comprehensive plan to guide interpretation of monitoring results and consideration of potential effects on wildlife resources, if any measures are adjusted via adaptive management.

With the exception of measures regarding the bald eagle, which we discuss in section 3.3.5.2.7, *Threatened and Endangered Species*, and measures regarding managing upland vegetation, which we discuss in section 3.3.4.2.1, *Vegetation Management/Noxious and Invasive Species Control*, we discuss specific measures associated with the proposed, specified, and recommended wildlife management plans in the following section.

Wildlife Movement

Project canals and roads can create barriers to wildlife movement and mortalities. The 3,800-foot-long East Side water conveyance system on the east side of the Link River, the 5,600-foot-long West Side canal on the west side of the Link River, the approximately 2-mile-long J.C. Boyle canal along the J.C. Boyle bypassed reach, and the 4,600-foot-long Fall Creek canal, along Fall Creek, can cause disruption in wildlife movement by acting as barriers to migration. The East Side water conveyance system consists of a 3,100-foot-long flowline and 700 feet of canal and forebay. The flowline is mounted on concrete supports allowing between 0.5 and 3 feet of clearance under the pipe. One side of the East Side canal has earthen banks and the other side has a vertical concrete block wall less than 2 feet tall. No bridges cross the canal, but there is little to no barrier to animal entrance to the canal on either side. The West Side canal is built into the hill slope west of the Link River and is formed entirely by earthen banks with moderate to steep sloping terrain. There are no barriers for animal entrance to the canal on either side. About 600 feet from the intake at Link River dam, one 15- to 20-foot-wide vehicle bridge with a gravel surface crosses the canal. A 60-foot-long section of aboveground flowline is located at the southern end of the West Side canal, as well as a 60-foot-long section of flume serving as a spillway. The Fall Creek canal is relatively narrow (4 to 10 feet wide) with rock and earthen banks. The east (downslope) side of the J.C. Boyle canal is a 16-foot-tall concrete wall; the west (upslope) side of the

canal is a concrete wall that varies in height from less than 2 to 16 feet tall. Just over half of the west wall is less than 4 feet tall but is located in steep terrain and not likely to be used for wildlife movement. Except for two existing vehicle access points which also serve as wildlife escape points and the forebay, wildlife must currently travel around the ends of the J.C. Boyle canal.

To enhance wildlife connectivity in the J.C. Boyle bypassed reach, PacifiCorp proposes to install and maintain eight wildlife crossings on the J.C. Boyle canal: one 12-foot-wide big game crossing near the middle of the canal and seven small (about 2 feet wide) animal bridges and ramps along the canal. PacifiCorp proposes to provide crossings in sections of the canal that are near already documented big game trails, have both gentle to moderate terrain and low wall height on the west side, have relatively good access to the river and riparian habitat, and have adequate space for construction of access ramps on both sides of the canal. PacifiCorp proposes to implement a monitoring program developed in consultation with the resource agencies to document the use of the wildlife bridges and continue to record any mortalities or live entrapped animals observed at the J.C. Boyle and Fall Creek canals. PacifiCorp would prepare periodic reports for agency review and if design-related problems occur or if mortality becomes a problem, would consult with the resource agencies to implement additional measures.

There are about 48 miles of roads within the proposed project boundary, and about 54 percent of them are on PacifiCorp land. Roads are known to create barriers to wildlife movement and can cause direct wildlife mortality from collisions with vehicles. PacifiCorp proposes to finalize its road access management plan, in coordination with its wildlife resources management plan, which would assess the feasibility of closing unnecessary roads and establishing seasonal restrictions on unimproved roads to prevent resource damage and disturbance to wildlife during sensitive time periods. Additionally, PacifiCorp proposes to restore sites along roads that are known to have environmental damage. In its October 2004 draft Project Roadway Management Plan, PacifiCorp proposes closing 0.22 mile of road along the southern shoreline of the J.C. Boyle reservoir north of Sportsman's Park, as well as a 0.02-mile-long spur road on the western shoreline of Iron Gate reservoir.

The wildlife habitat management plan specified by the Bureau of Land Management includes measures for wildlife crossings and escape ramps for the J.C. Boyle canal and effectiveness monitoring.

Oregon Fish & Wildlife recommends that PacifiCorp install additional large animal wildlife crossings at least 36 feet wide and escape ramps at J.C. Boyle canal, within 2 years of license issuance. PacifiCorp would determine the number and locations of crossings that would maximize opportunities for wildlife movement through survey results and consultation with Oregon Fish & Wildlife and FWS. Oregon Fish & Wildlife also recommends that PacifiCorp install additional structures at project canals at least 2 feet wide to specifically provide crossing opportunities for small animals, within 2 years of license issuance. The design and location of these structures would be based on small mammal trapping and survey results and in consultation with Oregon Fish & Wildlife, FWS, and the Bureau of Land Management. Oregon Fish & Wildlife also recommends that PacifiCorp consult with it, FWS, and the Bureau of Land Management to develop a wildlife crossing monitoring plan to evaluate the efficacy of wildlife crossings along project canals and waterways within 1 year of license issuance. PacifiCorp would complete and implement the monitoring plan immediately upon installation of the new crossings and when upgrading existing crossings. Based on monitoring results, Oregon Fish & Wildlife suggests that it, FWS, and the Bureau of Land Management may require PacifiCorp to install additional wildlife crossings 5 years following license issuance. Finally, Oregon Fish & Wildlife recommends that PacifiCorp continue to maintain wildlife crossings and escape ramps at canals and waterways to prevent entrapment of wildlife and within 2 years of license issuance, consult with it, FWS, and the Bureau of Land Management, to prepare an annual inspection and maintenance report on the wildlife crossings and escape ramps; this annual inspection and maintenance report would be provided to the agencies by March 1 of each year.

Oregon Fish & Wildlife recommends that PacifiCorp continue to cooperate with it, the Bureau of Land Management, and major landowners in the project area to seasonally restrict motor vehicles during the critical winter period (the Pokegama seasonal road closure) to (1) reduce harassment to wintering big game and other wildlife, (2) improve law enforcement, and (3) reduce damage to roads and soils. Oregon Fish & Wildlife recommends that PacifiCorp continue maintenance activities including gate repair and appropriate signage to help achieve the closure objectives. Oregon Fish & Wildlife also recommends that PacifiCorp permanently close and rehabilitate any primitive roads within the project boundary that are identified as non-essential for public access or for project operation and maintenance.

In its response to Oregon Fish & Wildlife, in a letter filed with the Commission on May 12, 2006, PacifiCorp disagrees with Oregon Fish & Wildlife's recommendation for a 36-foot-wide big game bridge and states that this width is excessive and unsubstantiated. PacifiCorp also disagrees with the need for new small animal trapping and surveys prior to installing small animal crossings. PacifiCorp states that installation of the big game bridge and the small animal crossings should be after Commission approval of the wildlife habitat management plan rather than 2 years after license issuance. PacifiCorp points out that guidance for monitoring the crossings would be included in the wildlife habitat management plan and should be finalized after construction of the crossings, rather than within 1 year of license issuance. PacifiCorp disagrees with the recommendation that it evaluate the efficacy of the crossings because there is no reliable standard for judging efficacy. Finally, PacifiCorp states that it wishes to avoid unnecessary or duplicative reporting so the timing of any reports should be coordinated with the completion of appropriate plans and implementation of necessary actions.

Our Analysis

From 1983 until 2003, PacifiCorp reported no mortality of medium to large size wildlife at the East Side and West Side canal trashracks; however, it did not keep records on small animals that could pass through the 2-inch grates. From 1997 until 1999, when fyke nets were monitored as part of its sucker entrainment study, PacifiCorp discovered one double-crested cormorant, one muskrat, one mallard, one doe, and one unknown duck in the West Side canal fyke nets, all dead. It is possible that the duck, cormorant, mallard, and muskrat were in the canal voluntarily and were killed by becoming entangled in the sampling net. PacifiCorp was unable to determine if the deer was dead or alive when it entered the net or if it would have successfully escaped if it had not been caught in the net. PacifiCorp also observed live raccoon, salamanders, frog, beaver, pelican, bullfrog tadpoles, unidentified frogs, newt, western grebe, unidentified snake, and garter snake alive in the West Side canal. The tadpoles would likely have been washed into the penstocks, but the adult frogs and other species could have escaped along the gradual, vegetated slopes of the canal. PacifiCorp found a beaver, two newts, three unidentified frogs, one bullfrog tadpole, and an unidentified snake in the East Side canal fyke nets. The beaver had been swimming in the forebay, but was caught when the net was lifted. The East Side canal is very short so it is possible that the smaller animals passed through the trashrack grating at the diversion from Upper Klamath Lake.

Since 1988, PacifiCorp has documented six wildlife mortalities at the J.C. Boyle canal and forebay including four deer and one skunk collected from the J.C. Boyle forebay trashrack, and one deer mortality from jumping off of the J.C. Boyle canal emergency spillway. PacifiCorp documented deer mortalities in March, June, August, and September. Broken legs on two of the dead deer found in the J.C. Boyle canal suggest that they probably fell from the surrounding cliffs. PacifiCorp has not collected any deer from the trashrack since 1990. PacifiCorp has not assessed entrainment of small animals in this canal because the trashrack grates are too widely separated to stop small animals.

PacifiCorp did not document any wildlife mortality at the Fall Creek trashracks. However, it is possible that some small animals, especially amphibians and reptiles, enter the canal either at the diversion or along its length and then are passed through the Fall Creek powerhouse turbines because of the spacing of the trashrack grating.

PacifiCorp's review of studies addressing the effects of hydroelectric projects on wildlife movement and habitat connectivity revealed that, in some cases, project waterways do not prevent movement throughout the landscape, but may alter movement patterns or corridors, which, in turn, may make animals more susceptible to predation or hunting mortality. Another study showed that deer were found to use different crossing locations during spring and fall migration periods, suggesting that location of escape mechanisms in canals is extremely important because animals cross at specific locations. Several studies demonstrated that deer bridges and escapes are effective at reducing mortality.

It is unlikely that the J.C. Boyle bypassed reach is used consistently by big game due to its steep and rocky nature. However, through its field surveys, PacifiCorp determined that several small mammal species, particularly the deer mouse, bushytail woodrat, dusky-foot woodrat, montane vole, canyon mouse, and least chipmunk, were relatively common immediately along one or more of the canals, and several species of snakes and lizards also were found using habitats along the J.C. Boyle canal. It is possible that lizard species could climb the concrete walls of the J.C. Boyle canal while the other species would be able to access the inside of the canal only at certain locations with low or no walls. The J.C. Boyle canal probably blocks movement by individual terrestrial mammals and reptiles. The effect likely is limited to individuals, but enhancing crossing opportunities could benefit local populations.

PacifiCorp proposes to install and maintain eight wildlife crossings on the J.C. Boyle canal and develop a monitoring program to document the use of the wildlife bridges. The Bureau of Land Management specified and Oregon Fish & Wildlife recommended wildlife crossings and escape ramps for the J.C. Boyle canal and effectiveness monitoring. Providing wildlife crossings that connect suitable habitat would eliminate a need for animals to enter the J.C. Boyle canal and would ultimately enhance connectivity. Oregon Fish & Wildlife recommends that PacifiCorp consult with it, FWS, and the Bureau of Land Management to develop a wildlife crossing monitoring plan to evaluate the efficacy of wildlife crossings along project canals and waterways within 1 year of license issuance, but recommends installation of the wildlife crossings within 2 years of license issuance. We do not consider it appropriate to install wildlife crossings prior to completion and approval of a comprehensive wildlife resource management plan, which would encompass monitoring enhancement measures as part of the plan. Oregon Fish & Wildlife also recommends that PacifiCorp prepare an annual inspection and maintenance report on the wildlife crossings and escape ramps beginning within 2 years of license issuance. Again, any specific inspection and maintenance procedures would be defined in the comprehensive wildlife resource management plan. Monitoring wildlife use of any crossings that may be installed would enable consulted entities to assess effectiveness. However, a determination of effectiveness would be somewhat subjective, because it would not be possible to determine whether wildlife that use the crossings would have chosen not to cross the canal if the crossings were not provided, and if not, whether this would adversely influence any life history function.

Roads throughout the project vicinity potentially can affect small animal connectivity and be a source of mortality. PacifiCorp documented 30 wildlife mortalities on roads traveled by project personnel during the spring and summer of 2003. The majority of the observed carcasses were California ground squirrels. PacifiCorp also found seven snake carcasses along these roads during that time period and observed five live snakes basking on roads. Four of the carcasses were found on roads most heavily used for project purposes, while three were on more heavily traveled public roads. PacifiCorp reported that wildlife mortality appeared to be most evident along road sections with relatively high traffic volumes and those areas with visitor access and potential for higher vehicular speeds.

Most PacifiCorp roads are located near the Keno, J.C. Boyle, Copco No. 1 and No. 2 dams, and Iron Gate reservoir. PacifiCorp proposes to finalize its road access management plan, whereby it would assess the feasibility of closing unnecessary roads and establishing seasonal restrictions on unimproved roads to prevent resource damage and disturbance to wildlife during sensitive time periods. Additionally, PacifiCorp proposes to restore sites along roads that are known to have environmental damage. PacifiCorp has already proposed closing 0.22 mile of road along the southern shoreline of the J.C. Boyle

reservoir north of Sportsman's Park, as well as a 0.02-mile-long spur road on the western shoreline of Iron Gate reservoir. Even though wildlife mortality due to roads at the Klamath Hydroelectric Project is relatively light, wildlife would benefit from closing and restoring roads, due to the maintenance of wildlife habitat connectivity and limited opportunity for collisions with vehicles.

Avian Transmission Line Protection

PacifiCorp has retrofitted most of its project transmission lines to raptor-safe standards; however, Line 15, located south of the Copco No. 2 bypassed reach, still has a few poles with configurations that do not meet current raptor electrocution safety standards. Although PacifiCorp has not documented any avian electrocutions or avian collision deaths along the project transmission lines since its personnel began tracking them in the late 1980s, avian mortalities are still possible. Additionally, transmission lines located near areas of high waterfowl and wading bird use are of particular concern because waterfowl and other large-bodied birds are most at risk of colliding with the transmission lines. To document bird mortalities that may have resulted from electrocution or collision at their transmission lines, PacifiCorp follows guidelines included in its memorandums of understanding with Oregon Fish & Wildlife, Cal Fish & Game, and FWS for reporting, removing, and disposing of electrocuted birds. These guidelines include mortality reporting, bird power line management program guidelines, and raptor-safe distribution line construction standards.

PacifiCorp proposes to continue to maintain its database of all reported electrocutions and to continue to support the memorandums of understanding with Oregon Fish & Wildlife, Cal Fish & Game, and FWS. PacifiCorp also proposes to continue to monitor all power lines within the project boundary and, whenever feasible, to retrofit structures where avian electrocutions have occurred. PacifiCorp proposes to conduct baseline monitoring surveys once during the first year following license acceptance to search for dead birds under its transmission lines within the project boundary and also to conduct additional power line monitoring during the first several years after license acceptance. Remedial actions would be conducted whenever feasible where dead birds are found, and a follow-up survey would be conducted the following year. If no more dead birds are found, PacifiCorp proposes to follow its standard monitoring and reporting method thereafter.

FWS recommends that PacifiCorp consult with it, the Bureau of Land Management, the Forest Service, and Oregon Fish & Wildlife within 1 year of license issuance to complete an avian collision and electrocution hazard avoidance plan to ensure that adverse interactions between project transmission and distribution lines and birds are minimized. FWS recommends including monitoring strategies in the plan that are sufficiently repetitive to detect sites causing mortalities and that any pole or tower involved in a bird fatality and all new or rebuilt power poles conform to guidelines established by the Avian Power Line Interaction Committee and FWS. FWS recommends that PacifiCorp develop and implement this plan based on the existing Avian Protection Plan for the Klamath Basin (PacifiCorp and FWS, 2005, as cited in the letter from Interior to the Commission dated March 27, 2006) and upon any existing memorandums of understanding between PacifiCorp, FWS, and other agencies. If deemed necessary by the Forest Service or the Bureau of Land Management, FWS recommends that PacifiCorp develop a memorandum of understanding specific to the Klamath Hydroelectric Project in consultation with those agencies and file it with the Commission for approval within 2 years of license issuance.

In its response to FWS, in a letter filed with the Commission on May 15, 2006, PacifiCorp states that there has been no indication that project-related transmission lines are causing bird mortalities. It does not believe that developing another plan, more memorandums of understanding, or implementation of other measures are needed to reduce avian interactions with power lines within the project boundary.

Oregon Fish & Wildlife recommends that PacifiCorp implement measures to minimize adverse interactions between project power lines and birds including (1) retrofitting or rebuilding any power pole involved in a bird fatality to increase safety for large perching birds; and (2) constructing new or rebuilt

power poles in accordance with guidelines in the most current edition of *Avian Protection Plan Guidelines* (APLIC, 2005) which is to be used in conjunction with *Suggested Practices for Raptor Safety on Power Lines: The State of the Art in 1996* (APLIC, 1996) and *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994* (APLIC, 1994). Oregon Fish & Wildlife recommends that PacifiCorp install bird flight diverters on any new transmission lines and that it retrofit any existing transmission lines that have been documented to cause mortality. Oregon Fish & Wildlife recommends that PacifiCorp conduct operation and maintenance activities in the project area in accordance with the most current spatial and temporal guidelines for avian protection (APLIC, 1996 and 2005). Oregon Fish & Wildlife also recommends that PacifiCorp follow the existing Agreement for Management of Birds on Powerlines between PacifiCorp, Oregon Fish & Wildlife, and FWS dated February 18, 1988. According to Oregon Fish & Wildlife, the agreement promotes cooperation between PacifiCorp and the signatory agencies and includes procedures for dealing with bird mortality and problem nests. According to Oregon Fish & Wildlife, records of dead birds found near project facilities are kept in a database, and annual reports summarizing avian protection program activities within the project area are submitted to Oregon Fish & Wildlife, FWS, and the Bureau of Land Management.

In its response to Oregon Fish & Wildlife, in a letter filed with the Commission on May 12, 2006, PacifiCorp states that it does not believe that the conditions recommended by Oregon Fish & Wildlife to minimize adverse interactions between project power lines and birds are necessary because PacifiCorp is already implementing a company-wide program to minimize adverse interactions between power lines and birds that includes all project-related lines. PacifiCorp states that its company-wide program and memorandums of understanding address all power lines in a comprehensive manner and already provide adequate protection for the resource.

In its comments on the draft EIS, PacifiCorp notes that its bird management program practices were updated in June 2006 and are consistent with the latest 2005 Avian Protection Plan guidelines. PacifiCorp also proposes to add provisions to allow updating practices to the avian protection element of the wildlife management plan. Also, PacifiCorp states that it would continue to support existing agreements and the most current spatial and temporal guidelines for avian protection.

Our Analysis

Approximately 67 percent of all birds documented by PacifiCorp during its field surveys were waterfowl and other water-related birds. PacifiCorp observed 47 species of water birds including 20 species of waterfowl and 19 species of open-water, marsh, and wading birds other than waterfowl. Additionally, PacifiCorp documented 19 birds of prey, including six species of hawk, two eagle species, three falcon species, seven owl species, and one species of vulture. Fourteen of these species of birds of prey have special status as do seven of the water-related birds.

PacifiCorp evaluated the potential of the transmission lines to cause raptor electrocutions. Most electrocutions occur when spacing between energized conductors or between conductors or grounding sources are less than 60 inches, or when poles are configured such that birds can come into contact with transformers, lightning arrestors, jumper wires, or switches (APLIC, 1996). PacifiCorp found that Line 15, located south of the Copco No. 2 bypassed reach, still has a few poles with configurations that do not meet current raptor electrocution safety standards. All other support structures meet current Avian Power Line Interaction Committee guidelines, and there are no records of electrocutions in the past.

PacifiCorp evaluated the potential of the transmission lines to cause raptor collision mortality. Collision risk is generally highest when transmission lines cross flight paths that birds use during seasonal migration or daily movements between foraging and roosting areas (APLIC, 1996). Most collisions occur where power lines cross rivers, reservoirs, wetlands, or flooded fields, and involve ducks, geese, and other large waterbirds such as great blue herons that are less maneuverable in flight than raptors. PacifiCorp determined that there are four segments of project transmission lines located near areas of high waterfowl

and wading bird use: one at Link River, one near the upstream end of Iron Gate reservoir, and two segments of line that cross Iron Gate reservoir. At Link River, the transmission line crosses a flight corridor between Upper Klamath Lake and Keno reservoir heavily used by many ducks, waterbirds, and colonial nesting wading birds that fly between the two water bodies to forage and roost. The line segment at the upper end of Iron Gate reservoir crosses Fall Creek before it parallels a part of the reservoir heavily used by shorebirds and waterfowl. One of the segments of line crossing Iron Gate reservoir crosses the Jenny Creek inlet, which is an area consistently used by many ducks, waterbirds, and colonial nesting wading birds. The other segment of line crosses Iron Gate reservoir more than half a mile south of the mouths of Camp and Scotch creeks, which is also an area of concentrated waterfowl use. No bird mortalities or collision-induced power outages have been reported from these lines. In fact, PacifiCorp's avian mortality databases indicates that no collisions or electrocutions have been documented by PacifiCorp personnel since implementing memorandums of understanding with Oregon Fish & Wildlife and Cal Fish & Game in the late 1980s.

PacifiCorp proposes to continue to support the memorandums of understanding with Oregon Fish & Wildlife, Cal Fish & Game, and FWS. The memorandums of understanding have been in place since the late 1980s and provide guidelines for the reporting and disposal of birds found near PacifiCorp lines or facilities. The guidelines include (1) mortality reporting-PacifiCorp employees report any large dead bird found in or around project facilities; since 1988, PacifiCorp has maintained a bird mortality tracking system where all observations are documented; (2) bird power line management program guidelines - created for PacifiCorp field employees and distributed to all offices (most recently in early 2006) to provide information on mortality reporting forms, agency contacts, raptor identification, and information for making existing structures raptor-safe; and (3) raptor-safe distribution line construction standards - new and rebuilt rural distribution lines require a minimum of 60 inches of clearance between conductive or conductive and grounded parts of a transmission line to meet raptor-safe construction standards. Problem poles, where an eagle or other birds have been killed, also are identified and retrofitted with insulator covers, brushing caps, triangles or perches, or jumper wire hose when feasible or replaced if they cannot be retrofitted adequately.

According to the April 2005 version of the Avian Protection Plan Guidelines, power lines are considered avian-safe (will prevent electrocutions) if they are designed and constructed to provide conductor separation of 60 inches between energized conductors and grounded hardware, or if energized parts and hardware are covered if such spacing is not possible. PacifiCorp's construction standards clearly meet the guidelines.

We conclude that the risk of electrocution or collision is low at the Klamath Hydroelectric Project because (1) only one of PacifiCorp's transmission lines does not meet current Avian Power Line Interaction Committee guidelines, (2) no bird mortalities or collision-induced power outages have been reported from lines located near areas of high waterfowl and wading bird use, and (3) PacifiCorp's new and rebuilt rural distribution lines require a minimum of 60 inches of clearance between conductive or conductive and grounded parts of a transmission line to meet raptor-safe construction standards. We also conclude that risks at the Klamath Hydroelectric Project have been further reduced by the existing memorandums of understanding that provide guidelines for monitoring, tracking, and reporting adverse avian power line interactions. PacifiCorp indicated that its most current edition of its bird power line management program guidelines reflect the Avian Protection Plan Guidelines as updated by the Avian Power Line Interaction Committee and FWS in 2005 and distributed in early 2006. It is possible that revisions to guidelines for raptor protection at transmission lines would occur during the term of the new license and PacifiCorp proposes incorporating provisions to respond to updated protection guidelines when support structures need replacement or repair into the avian protection element of a wildlife management plan.

FWS recommends that PacifiCorp develop an avian collision and electrocution hazard avoidance plan to ensure that adverse interactions between project transmission and distribution lines and birds are

minimized. PacifiCorp has pointed out, and we agree, that there has been no indication that project-related transmission lines are causing bird mortalities. PacifiCorp proposes to include avian protection as an element of a comprehensive wildlife resource management plan, and would address monitoring project transmission lines and retrofitting structures where avian electrocutions have occurred.

Oregon Fish & Wildlife recommends that PacifiCorp implement several measures to minimize adverse interactions between project power lines and birds, including retrofitting or rebuilding any power pole involved in a bird fatality to increase safety for large perching birds and constructing new or rebuilt power poles in accordance with the most current guidelines. PacifiCorp has not proposed any new transmission lines at the project but has proposed including avian protection as an element of a comprehensive wildlife resource management plan, and would address monitoring project transmission lines and retrofitting structures where avian electrocutions have occurred. Oregon Fish & Wildlife also recommends that PacifiCorp continue to follow the existing Agreement for Management of Birds on Powerlines between PacifiCorp, Oregon Fish & Wildlife, and FWS dated February 18, 1988. We have not obtained a copy of this agreement, but PacifiCorp explicitly states that it would continue to support it. Oregon Fish & Wildlife also recommends that PacifiCorp conduct operation and maintenance activities in the project area in accordance with the most current spatial and temporal guidelines for avian protection. We assume that Oregon Fish & Wildlife was referring to the operation and maintenance of the project transmission lines, which is what the Avian Power Line Interaction Committee guidelines address.

Special Status Wildlife

Several sensitive wildlife species occur within the project boundary. Of these, the western toad, northwestern pond turtle, the Yuma myotis, and the Pacific western big-eared bat could potentially be affected by project operations. The western toad occurs in the J.C. Boyle peaking reach, along the north shore of Iron Gate reservoir, and along the Klamath River between the confluence of Bogus and Cottonwood creeks. All known western toad breeding sites are located along Iron Gate reservoir, and daily water level fluctuations in the reservoir could potentially affect breeding western toads, from February until early May. PacifiCorp proposes to try to minimize Iron Gate reservoir fluctuations from March until July during the spring and summer amphibian and waterfowl breeding season by scheduling routine maintenance drawdowns outside of this time period, but recognizes that future water level fluctuations may be similar to current water level fluctuations due to daily and weekly project operations. Therefore, as part of its wildlife habitat management plan PacifiCorp proposes to create a small (less than 0.5-acre) swale near the current toad breeding site on Iron Gate reservoir just west of Scotch Creek. PacifiCorp believes that the swale would be sufficiently isolated from the reservoir to prevent predatory fish from entering it, and it would be designed to hold surface water at a more stable level than can occur in the reservoir and provide better conditions for developing egg masses, tadpoles, and larvae.

Western pond turtles occur at several locations throughout the project area, but are concentrated in locations where basking structures (exposed rocks and occasionally logs) are present near slack water. The water level fluctuations in the river reaches and reservoirs may adversely affect turtles by making some of the basking sites unavailable, increasing the risk of predation, and reducing forage resources. Project recreation also affects western pond turtles because several basking sites and nesting sites are located near recreational sites (Frain Ranch, Klamath River Campground), and basking turtles are regularly disturbed by whitewater rafters. PacifiCorp expects that its proposed changes in operation of the J.C. Boyle powerhouse would enhance conditions for turtles in the J.C. Boyle peaking reach by increasing the amount of permanently inundated aquatic habitat, decreasing the width of the exposed varial zone that turtles would have to navigate to reach upland habitats, and slowing the ramping rate. As part of its wildlife habitat management plan, PacifiCorp proposes to add basking structures (rocks, tethered logs, or other permanent objects that cannot be flushed downstream) at selected sites on reservoirs or in backwater turtle habitat. PacifiCorp would determine the number and distribution of these

structures based on known turtle concentrations, locations of recreational activity, and suitability of adjacent uplands for nesting and overwintering.

Yuma myotis are known to use various project buildings including the Copco No. 1 powerhouse, Copco No. 1 gatehouse, the Copco No. 2 dam gatehouse, and the Copco No. 2 powerhouse. Most buildings are used by small numbers of bats without much conflict with project operations. However, at Copco No. 2 powerhouse, PacifiCorp's annual operation of the crane mechanism on the ceiling track sometimes kills a small number (three or four) of bats that are roosting inside the mechanism. As part of its wildlife habitat management plan, PacifiCorp proposes to install bat roost structures outside of the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate facilities to provide safer roost sites. PacifiCorp also proposes to investigate the feasibility of excluding bats from at least the most dangerous sites to minimize the possibility of direct mortality and would implement such measures if feasible.

PacifiCorp proposes to expand or add 10 recreation sites near the project (Boyle Bluffs recreation area, J.C. Boyle car-top boat launch, J.C Boyle loop trail, J.C Boyle dam river access and trails, J.C. Boyle powerhouse river access and trail, Fall Creek trail extension, Wanaka Springs modification, Camp Creek expansion, Long Gulch Bluff recreation area, and Bogus Creek trail) which would affect approximately 79 acres of wildlife habitat. Most of the habitat is montane hardwood oak-juniper (40 acres) and annual grassland (28 acres); no wetland or riparian habitat would be affected. As part of its wildlife habitat management plan, PacifiCorp proposes to survey for special status plant and wildlife species and significant wildlife habitat or use areas prior to conducting ground-disturbing activities. PacifiCorp proposes to provide the results of the surveys to the resource agencies and develop site-specific mitigation plans for each site that may include use of native plant species; potential seasonal restrictions; and if necessary, on-site or off-site habitat replacement.

The wildlife habitat management plan specified by the Bureau of Land Management includes measures for western pond turtle habitat and effectiveness monitoring and sensitive and special status species surveys and monitoring including (1) protocols for long-term surveys and monitoring of sensitive species and their habitat for Bureau of Land Management-administered lands within the project boundary to assess effects and develop necessary mitigation; (2) identification of restoration, protection, and/or enhancement measures for sensitive species; and (3) seasonal restrictions for active nest sites on Bureau of Land Management-administered lands for golden eagles, ospreys, peregrine falcons, and other raptors that are affected by project operations.

Our Analysis

All known western toad breeding sites are located along Iron Gate reservoir, and daily water level fluctuations in the reservoir could potentially affect breeding western toads, which typically breed between January and September. Western toads attach long strings of eggs in a jelly-like substance to vegetation in still, shallow water. The tadpoles emerge from the eggs and live in the shallows feeding on vegetation until they lose their tails and metamorphose into toads. In 2002, the Iron Gate western toad breeding site was apparently unsuccessful, while in 2003, numerous young toads were produced at the same site. In 2002, the Iron Gate western toad breeding site experienced a 2-foot water level drop during egg development, which entirely dried the egg strands. New egg strands were found in the shallow water near the new lower water line. By May 10, 2002, the reservoir had been refilled and had deeply inundated the eggs that were found on April 25, 2002. This rapidly fluctuating water level likely resulted in either desiccation or detachment of the egg masses, which would increase their exposure to predation by yellow perch and bullfrogs. However, PacifiCorp observed numerous (more than 100) western toad egg strings at the Iron Gate breeding site in early spring 2003. PacifiCorp subsequently confirmed successful hatching and dispersal of metamorphosed juvenile toads from the site.

PacifiCorp's proposals to try minimizing Iron Gate reservoir fluctuations from March until July and create a small (less than 0.5-acre) swale near the current toad breeding site would minimize water

level fluctuations during the breeding season and provide stable habitat, thus facilitating survival and maturation of the western toad egg strings. If PacifiCorp discontinues its peaking operation, this measure would no longer be necessary.

Western pond turtles have been found in the project vicinity in a variety of aquatic habitats and are common to abundant in many project reservoirs and river reaches. In general, the combination of relatively low-gradient flow, adequate food supplies, presence of adequate basking structures (emerging boulders, mats of emergent vegetation, or logs), and access to suitable nesting habitat is required for consistent western pond turtle use. Basking sites for thermoregulation are an important component of western pond turtle habitat. Few basking structures are located downstream of some of the project facilities, and the existing structures are used extensively by turtles in the project area. PacifiCorp proposes to add basking structures (rocks, tethered logs, or other permanent objects that cannot be flushed downstream) at selected sites on reservoirs or in backwater turtle habitat. The wildlife habitat management plan specified by the Bureau of Land Management includes measures for western pond turtle habitat and effectiveness monitoring. Providing additional basking structures would compensate for project peaking operations and whitewater boating flows, which result in inundation of basking habitat and displacement of turtles downstream. Additional basking structures should accommodate more turtle basking at different surface water elevations, thus enhancing the ability of the turtles to thermoregulate. Basking structures also would provide foraging and roosting habitat for other wildlife species using the project area.

Bats roosting in project structures can create human health issues for personnel engaged in operations and maintenance activities in the structures. Conversely, routine operations and maintenance activities can disturb roosting bat colonies and disrupt breeding activities. Providing alternative roosting sites outside of the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate facilities can reduce these potential adverse effects on humans and bat species with special status, as well as other bat species using the project area. Implementing measures to exclude bats from the most dangerous project sites would minimize the possibility of bat mortality and enhance survival of sensitive species.

PacifiCorp proposes to survey for special status plant and wildlife species and significant wildlife habitat or use areas prior to conducting ground-disturbing activities. PacifiCorp proposes to provide the results of the surveys to the resource agencies and develop site-specific mitigation plans for each site that may include use of native plant species, potential seasonal restrictions, and if necessary, on-site or off-site habitat replacement. Surveys would provide baseline data on species using areas proposed for disturbance and could guide decisions on methods and timing of ground-disturbing activities. Site-specific plans for avoiding or minimizing the biological effects of current and proposed project recreational facilities and related activities would provide a reasonable level of protection to biological resources in the project area. A more detailed discussion of the recreation resources management plan and associated monitoring is found in section 3.3.6, *Recreational Resources*.

3.3.4.2.3 Development Decommissioning and Dam Removal

Various entities have advocated the removal of some or all project dams to facilitate restoration of anadromous fish to historic habitat upstream of Iron Gate dam and as a potential means to enhance water quality in the Klamath River downstream of Iron Gate dam. Decommissioning and removing project dams would affect riparian habitat throughout the project area, from Keno reservoir to the Klamath River below Iron Gate dam. Riparian vegetation would likely re-establish along the banks of the new river channel in the reservoir reaches, while most of the area exposed by drawdown of each of the project reservoirs would be colonized by a mix of upland vegetation series, similar to those that are currently present. Assuming an average riparian corridor width of 100 feet along the 20.1-mile length of the Keno reservoir, the 3.6-mile length of the J.C. Boyle reservoir, the 4.5-mile length of the Copco No. 1 reservoir, the 0.3-mile length of the Copco No. 2 reservoir, and the 6.8-mile length of the Iron Gate reservoir, we estimate that decommissioning would add about 428 acres of riparian vegetation and about

3,950 acres of upland vegetation to the land base, as well as about 460 acres of riverine habitat in the areas now occupied by reservoirs.

The benefits that new riparian and upland areas might have as wildlife habitat would depend to a great extent on how they were restored and managed. If managed primarily for wildlife, the reservoirs could provide habitat for a variety of small mammals and songbirds, foraging opportunities for raptors, and high-quality winter range for deer. If managed strictly to re-establish plants on exposed surfaces, without concern for species type, no active management intervention may be needed (Orr and Stanley, 2006). However, based on a study of vegetative colonization following 13 dam removals in Wisconsin, introduced species such as reed canary grass (also common along the Klamath River) were a regular and often abundant component of the plant communities at the former reservoir sites (Orr and Stanley, 2006). The authors suggest that active seeding and planting of native species following dam removal may minimize invasive species colonization, although this approach is untested.

The loss of a total of about 4,840 reservoir acres would reduce the area of resting habitat for migratory waterfowl. The loss of open water habitat would also reduce foraging opportunities for osprey, bald eagles, and other piscivorous birds, and for several species of bats. Nesting habitat for waterfowl also could be reduced with the conversion of the Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate reservoirs to riverine or upland environments. Depending on the hydrologic characteristics following dam removal, there could actually be an increase in wetland habitat at some locations, which may offer an increase in nesting habitat for certain species of waterfowl. Of the 30 post-dam removal vegetation sites evaluated by Orr and Stanley (2006), one was an active wetland restoration project. Of the remaining 29 sites, active post-dam removal restoration (planting native vegetation, removal of undesirable species) was occurring at only two, relatively recently removed, dam sites. The authors conclude that this trend reflects a new and growing awareness of the opportunities presented during dam removal to improve riparian and wetland habitat along with the riverine environment.

A return to unregulated flows in the Klamath River would increase the average annual flow and the magnitude and frequency of floods. Klamath River flows would likely continue to be regulated to some degree because of operations of the Klamath Irrigation Project. Adverse effects would be likely to occur within the first few years following project or dam decommissioning and removal, as a result of erosion, bank failure, development of debris jams and gravel bars, scour, deposition, and changes in side channel connections. Such effects would need to be addressed in a dam or project decommissioning proceeding. However, riparian systems are characteristically resilient, and over time, riparian plant and wildlife communities along the Klamath River would likely equilibrate to changes in seasonal flows and changes caused by those flows.

3.3.4.3 Unavoidable Adverse Effects

None.

3.3.5 Threatened and Endangered Species

3.3.5.1 Affected Environment

3.3.5.1.1 Lost River and Shortnose Sucker

The Lost River sucker (*Delistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) are large, long-lived fish species that occur in the upper portions of the Klamath River Basin. Both species are known to occur in Upper Klamath Lake and its tributaries; the Lost River; Tule Lake; Clear Lake; and

Gerber,[104] J.C. Boyle, Copco, and Iron Gate reservoirs. These two sucker species primarily reside in lake habitats and spawn in tributary streams or at springs and shoreline areas within Upper Klamath Lake. Historically, the two species were very numerous in the shallow lakes that occurred in the upper basin, but most of these lakes have been substantially altered and reduced in size to support agricultural development. Native Americans and white settlers exploited concentrations of migrating and spawning suckers as a food source.

Although Tule Lake once supported a large population of suckers, habitat conditions there are currently degraded and the lake now supports only a few hundred suckers. Upper Klamath Lake currently supports the largest remaining population of both species (FWS, 2002a). Recent sampling conducted in the J.C. Boyle, Copco, and Iron Gate reservoirs indicate that the populations in these reservoirs are not large, and they appear to be supported by downstream movement of fish from Upper Klamath Lake (Desjardins and Markle, 2000). The number of suckers collected from the Klamath reservoirs and from the Klamath River in the project area is reported in section 3.3.3.1.1, *Aquatic Habitat Conditions*.

Both species of suckers were listed as endangered by FWS on July 18, 1988,[105] which issued a recovery plan for the listed suckers in 1993 (FWS, 1993). Several petitions have been filed to delist the species based on new information on the abundance and geographic range of the species. On May 14, 2002, FWS published a 90-day finding that the petitions did not present substantial scientific or commercial information indicating that delisting was warranted.[106] This initial finding was remanded on September 3, 2003, and FWS published a revised 90-day finding on July 21, 2004, again concluding that delisting was not warranted, but also stating that FWS would initiate a 5-year review of the listing of these species.[107] FWS proposed to designate a total of about 182,400 hectares (456,000 acres) of stream, river, lake, and shoreline areas as critical habitat for the shortnose sucker, and about 170,000 hectares (424,000 acres) of stream, river, lake, and shoreline areas as critical habitat for the Lost River sucker on December 1, 1994.[108] However, no critical habitat for these species has been designated to date.

At the time that the species were listed, FWS found that survey work performed from 1984 through 1986 indicated that there had been drastic declines in the population of both species in Upper Klamath Lake.[109] During the 1984 survey, the population of shortnose suckers moving out of Upper Klamath Lake in the spawning run was estimated at 2,650 individuals, but the 1985 and 1986 surveys found too few shortnose suckers to accurately estimate the population size. The catch per unit effort of shortnose suckers declined 34 percent between 1984 and 1985 and 74 percent between 1985 and 1986. The estimated spawning population of Lost River suckers in Upper Klamath Lake declined from 23,123 fish in 1984 to 11,861 fish in 1985. They found that no significant recruitment into the adult population of either species had occurred in approximately 18 years.

In its 2004 revised 90-day petition finding, FWS concluded that, although some population increase had occurred in the mid-1990s following closure of the sport fishery and good recruitment in 1991, 3 consecutive years of water quality-related die-offs in 1995 through 1997 killed a major portion of

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[104]Clear Lake and the Gerber reservoir, which were historically part of Lower Klamath Lake, are currently used to store and convey water as part of the Klamath Irrigation Project (see figure 2-4).

[105]53 FR 27,130-27,134.

[106]67 FR 34,422-34,423.

[107]69 FR 43,554-43,558.

[108]59 FR 61,744-61,759.

[109]53 FR 27,130-27,134.

the adult populations.[110] Following these die-offs, the number of suckers spawning in the Sprague River declined 80 to 90 percent based on weekly netting surveys conducted during the spawning season.

The 1988 notice listing the Lost River and shortnose suckers and status assessments in two BiOps on Reclamation's operation of the Klamath Irrigation Project (FWS, 2001a; 2002a) concluded that the species were subject to the following threats: (1) drastically reduced adult populations and reduction in range; (2) extensive habitat loss, degradation and fragmentation; (3) small or isolated adult populations; (4) isolation of existing populations by dams; (5) poor water quality leading to large fish die-offs and reduced fitness; (6) lack of sufficient recruitment; (7) entrainment into irrigation and hydropower diversions; (8) hybridization with the other native Klamath sucker species; (9) potential competition with introduced exotic fishes; and (10) lack of regulatory protection from federal actions that might adversely affect or jeopardize the species.

The 2002 FWS BiOp (FWS, 2002a) found that Reclamation's 10-year operating plan was likely to jeopardize the survival of Lost River and shortnose suckers based on the effects of sucker entrainment at project dams[111] and diversions in Upper Klamath Lake, effects of project operations on water quality in Upper Klamath Lake, and sucker habitat loss in Upper Klamath Lake. FWS identified a reasonable and prudent alternative that included three primary elements and four sub-elements: (1) maintaining higher water levels in Upper Klamath Lake by using the 50 percent exceedance forecast to determine minimum lake levels instead of the 70 percent exceedance forecast proposed by Reclamation; (2) reducing the entrainment of juvenile, sub-adult and adult suckers at Link River dam and associated hydropower intake bays; and (3) (a) developing a DO risk assessment model for Upper Klamath Lake and incorporating results into project management; (b) assessing and managing Upper Klamath Lake sucker water quality refuge areas; (c) assessing ongoing sucker population monitoring and implementing needed monitoring improvements; and (d) developing and implementing a sucker die-off assessment plan.

Measures that have been implemented to benefit the listed suckers since the 2002 BiOp include maintaining higher lake levels in Upper Klamath Lake, the installation of fish screens at the Reclamation's A canal diversion in 2003, and the installation of a new fish ladder at Link River dam in 2005 to enable suckers that pass downstream over Link River dam to migrate upstream back into Upper Klamath Lake.

3.3.5.1.2 Coho Salmon

Coho salmon (*Oncorhynchus kisutch*) in the Klamath River are part of the Southern Oregon/Northern California Coast coho salmon ESU (the SONCC coho salmon ESU), which includes all naturally spawned populations and their progeny in streams between Cape Blanco in southern Oregon and Punta Gorda in northern California. NMFS listed this ESU as threatened on May 6, 1997,[112] and critical habitat was designated on May 5, 1999.[113] The California Fish and Game Commission found that the ESU warranted listing under the California Endangered Species Act as a threatened species on August 30, 2002, but they elected not to formally list the species while a recovery strategy was being prepared. The recovery strategy was completed in 2004 (Cal Fish & Game, 2004b). NMFS issued a Magnuson-Stevens Reauthorization Act (MSRA) coho recovery plan on July 10, 2007, and is in the process of preparing an ESA recovery plan for the SONCC coho salmon ESU. In this section we describe the species designated

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[110] 69 FR 43,554-43,558.

[111] In addition to Link River dam, Reclamation manages operation of five other primary dams within the Lost River and Tule Lake system: Clear Lake, Gerber, Malone, Wilson, and Anderson-Rose dams.

[112] 62 FR 24,588-24,609.

[113] 64 FR 24,049-24,062.

critical habitat, the status of the SONCC coho salmon ESU at the time that it was listed, available information on abundance trends since listing, and measures that are being undertaken to promote recovery of the ESU. Information on the species biology and population trends within the Klamath River Basin itself is presented in section 3.3.3.1.2, *Anadromous Fish Species*.

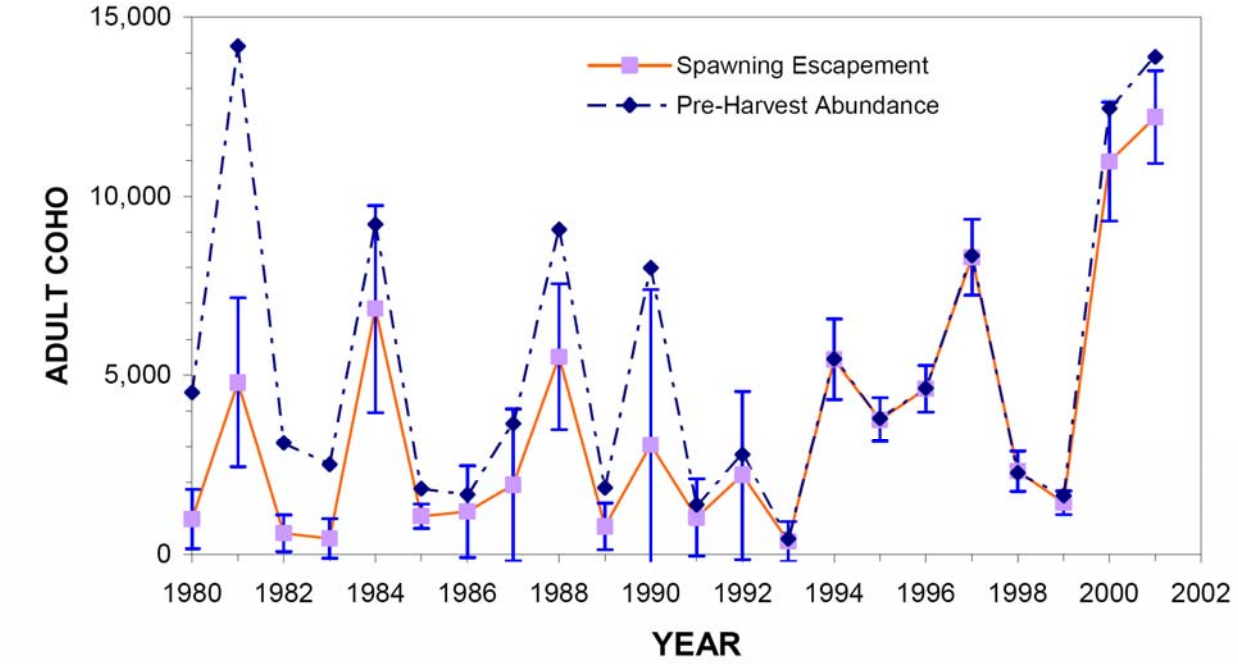
Within the Klamath River Basin, designated critical habitat for the SONCC coho salmon ESU includes all rivers within accessible reaches including estuarine areas and tributaries, excluding areas on tribal lands. NMFS concluded that the current range of the species encompasses all essential habitat features and is adequate to ensure the species conservation, and excluded habitat upstream of existing impassable barriers including Iron Gate dam on the Klamath River, Dwinnell dam on the Shasta River, and Lewiston dam on the Trinity River. NMFS identified five essential habitat types for the SONCC coho salmon ESU: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. NMFS identified important features of coho salmon critical habitat including adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions.

In its May 6, 1997, final rule listing the SONCC coho salmon ESU, NMFS estimated that the coho salmon population within the ESU had declined from 150,000 to 400,000 naturally produced fish in the 1940s to less than 10,000 naturally produced adults at the time of listing.[114] Threats to the ESU identified in the final rule listing the ESU included habitat degradation, harvest, and artificial propagation, exacerbating the adverse effects of natural environmental variability brought about by drought, floods, and poor ocean conditions. For the two hatcheries in the Klamath basin, NMFS determined that the Trinity River Hatchery stock should be included in the ESU, and considered the relationship of the Iron Gate Hatchery stock to the ESU to be uncertain. Because none of the hatchery stocks were deemed to be essential to recovery of the ESU, hatchery stocks were not included in the listing. However, NMFS determined that the Trinity River Hatchery stock may play an important role in recovery efforts because there appears to be essentially no natural production in the Trinity basin.

NMFS recently completed an updated status review of federally listed ESUs of west coast salmon and steelhead (Good et al., 2005). They concluded that there is little trend data on adult returns for stocks in the California portion of the SONCC coho salmon ESU that are not substantially influenced by hatchery production. In the Oregon portion of the ESU, estimates of naturally produced adult coho salmon are available only for the Rogue River Basin. About half of the total spawning run in the Rogue River Basin is of hatchery origin and most of these fish return to the Cole Rivers Hatchery, rather than spawning in natural habitat (Good et al., 2005). Based on fin-mark observations during spawning-ground surveys, in recent years the percentage of natural spawners that are of hatchery origin has ranged from less than 2 percent in 2000 to 20 percent in 1998.

Although both short and long-term trends in naturally produced spawners in the Rogue River Basin are upward, Good et al. (2005) reports that this increasing trend is largely due to reduced harvest, as trends in pre-harvest recruits are smaller (figure 3-103). Estimates of the contribution of SONCC fish to harvest prior to listing of the ESU are not available but Good et al. (2005) concludes that ocean exploitation rates have dropped substantially in response to prohibitions on retaining wild (unmarked) coho salmon put in place in 1994 as well as restrictions imposed on Chinook salmon-directed fisheries. Additional detail on harvest management is given in 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*.

[114] 62 FR 24,588-24,609.



Note: Vertical bars represent 95 percent confidence intervals for estimates of spawner abundance.

Figure 3-103. Trends in wild spawning escapement and wild pre-harvest abundance of Rogue River coho salmon, 1980-2001. (Source: Jacobs et al., 2002)

Analysis of survey data from streams where coho salmon were historically known to occur within the SONCC coho salmon ESU indicate that the proportion of streams occupied by rearing coho salmon juveniles generally fluctuated between 36 and 61 percent between brood years 1986 and 2000 (Good et al., 2005). Occupancy rates were highest between brood years 1991 and 1997 (54 to 61 percent), then declined between 1998 and 2000 (39 to 51 percent) before rebounding in 2001. The number of streams surveyed in each year where data analysis had been completed ranged from 136 streams in 1986 to 396 streams in 2000. Although preliminary data indicated that 2001 was a strong brood year, data from only 52 streams had been analyzed at the time that the status review was published.

Cal Fish & Game's recovery strategy[115] for California coho salmon (Cal Fish & Game, 2004b) identifies 85 range-wide recommendations, 320 watershed recommendations for the SONCC coho salmon ESU, 205 watershed recommendations for the California Central Coast ESU, and 145 watershed recommendations specific to the Shasta and Scott basins as part of the Shasta-Scott Pilot Program. Of the 320 watershed recommendations that are not included within the Shasta-Scott Pilot Program, 116 recommendations pertain to the Klamath River Hydrologic Unit, 12 pertain to the Salmon River Hydrologic Unit, 15 pertain to the Shasta Valley and Scott River Hydrologic Unit, and 23 pertain to the Trinity River Hydrologic Unit. Most of the watershed recommendations relate to water management measures for increasing instream flows, improving fish passage, screening of irrigation diversions, enhancement measures to improve riparian habitat and to increase large woody debris, livestock

[115]The goal of this recovery strategy is to return coho salmon to level of sustained viability while protecting the genetic integrity of both the SONCC and California Central Coast ESUs, such that regulations or other protections under the California Endangered Species Act (FGC §2050 et seq.) are not necessary.

exclusion, sediment management, and the re-establishment of natural fire regimes to reduce the risk of severe fires.

There are 13 watershed recommendations identified in the Cal Fish & Game recovery strategy that specifically relate to the mainstem Klamath River. These include (1) development of an adaptive management plan for low flow emergencies; (2) developing a plan to restore and maintain tributary and mainstem habitat connectivity where low flow or sediment aggradation is restricting coho salmon passage; (3) conducting a feasibility analysis for coho salmon passage over Iron Gate and Copco dams to access historic habitat; (4) completing a comprehensive (Hardy Phase II) flow study for the mainstem Klamath River; (5) applying protective downramping rates at Iron Gate dam; (6) improving the water quality from the upper basin; (7) performing a cost/benefit analysis of full or partial removal of the Klamath Hydroelectric Project dams; (8) preserving and enhancing coldwater tributary flows; (9) studying and protecting temperature refugia; (10) addressing problems relating to water quality, disease, and hatchery operations; (11) restoring coarse sediment supply and transport near Iron Gate dam; (12) acquiring additional water for instream flows through conservation easements, purchase and/or transfer of water and water rights from willing sellers; and (13) funding a water master service at all diversions (Cal Fish & Game, 2004b).

Cal Fish & Game (2004b) estimated that the total cost of implementing its recovery strategy would be between 4.5 and 5 billion dollars, and although they did not attempt to quantify the economic benefits of recovery, they concluded that benefits are likely to exceed the cost of recovery. They state that the benefits of achieving recovery to the point of delisting include providing an economic stimulus to the coastal economy due to the lifting of regulatory requirements associated with a listed species, increased commercial land and water use activities, the flow of restoration dollars to economically depressed coastal communities, and the expansion of commercial, recreational, and tribal fisheries and the businesses and communities that depend on them.

NMFS' MSRA Coho Salmon Recovery Plan (2007) identifies six high priority recovery actions.

1. Complete and implement the NMFS recovery plan for the SONCC coho salmon under the ESA.
2. Restore access for coho salmon to the upper Klamath River Basin by providing passage beyond existing mainstem dams.
3. Implement fully the Trinity River Restoration Plan.
4. Provide incentives for private landowners and water users to cooperate in: (1) restoring access to tributary streams that are important for coho salmon spawning and rearing, and (2) enhancing mainstem and tributary flows to improve instream habitat conditions.
5. Continue to improve the protective measures already in place to address forestry practices and road building/maintenance activities that compromise the quality of coho salmon habitat.
6. Implement restorative measures identified through fish disease research results to improve the health of Klamath River coho salmon populations.

3.3.5.1.3 Bull Trout

Bull trout exhibit both resident and migratory life-history strategies. Migratory bull trout spawn in tributary streams where juvenile fish rear one to four years before migrating either to a lake (adfluvial form) or river (fluvial form). Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior. Bull trout are found primarily in cold streams, and water temperature above 15°C is believed to limit bull trout distribution (FWS, 2002c).

Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a watershed.

The populations of bull trout in the Columbia and Klamath rivers were listed as threatened by the FWS in 1998 (63 FR 31,647). The Jarbridge River population was listed on April 8, 1999 (64 FR 177,110), and the Coastal-Puget Sound and St. Mary-Belly River populations were listed in 1999 (64 FR 58,910), which resulted in all bull trout in the coterminous United States being listed as threatened. The five populations noted above are listed as distinct population segments; that is, they meet the joint policy of FWS and NMFS regarding the recognition of distinct vertebrate populations (61 FR 4,722). Reasons for the decline in the distribution and abundance of bull trout include habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, angler harvest and poaching, entrainment into diversion channels and dams, and introduced non-native species (FWS, 2002a).

FWS published a draft bull trout recovery plan in 2002, and critical habitat was designated in 2005 (70 FR 56,212). The critical habitat designation includes currently or historically occupied habitat that was found to be essential to the conservation of the species. A total of 42 stream miles and 33,939 acres of critical habitat was designated in the Klamath River Basin. The Upper Klamath Lake Subunit includes Agency Lake and part of Sun Creek, the Sycan Marsh Subunit includes the Sycan Marsh and part of Coyote and Long creeks, and the upper Sprague River Subunit includes parts of Boulder, Brownsworth, Deming, Dixon, Leonard, and Sheepy creeks and of the North Fork Sprague River.

In the final rule designating critical habitat, FWS discuss the potential for any bull trout that migrate into Agency Lake could be exposed to infection by *C. shasta*. They note, however, that infection and mortality from *C. shasta* is temperature dependant, and that Chinook salmon do not appear to be affected by *C. shasta* when water temperatures remain below 15°C, indicating that migrating bull trout may not be infected since they are unlikely to migrate into Agency Lake when the water is warm.

3.3.5.1.4 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) require the identification of essential fish habitat (EFH) for federally managed fishery species and the implementation of measures to conserve and enhance this habitat. The MSA, as amended, defines EFH as those waters and substrate necessary for fish use in spawning, breeding, feeding, or growth to maturity. The MSA requires federal agencies to consult with NMFS regarding activities that may adversely affect EFH. The implementing regulations for MSA allow for the integration of NEPA or ESA section 7 reviews with the analysis of proposed project effects on EFH.

Chinook, coho, and Puget Sound pink salmon are the only Pacific coast salmonid fish actively managed under the MSA. Freshwater EFH for coho and Chinook salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California. In amendment 14 to the Pacific Coast Salmon Plan, the Pacific Fishery Management Council identified dams that should be considered to represent the upstream extent of EFH, including Iron Gate dam on the Klamath River, Dwinnell dam on the Shasta River, and Trinity dam on the Trinity River.

There are four major components of EFH for these species including (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat. Chinook and coho salmon EFH includes the mainstem Klamath River upstream to Iron Gate dam and all of its major tributaries including the Shasta River upstream to Dwinnell dam, the Scott River, the Salmon River, the Trinity River upstream to Trinity dam, and the South Fork Trinity River.

3.3.5.1.5 Slender Orcutt Grass

FWS listed slender Orcutt grass (*Orcuttia tenuis*) as a threatened species on March 26, 1997 (FWS, 1997). Slender Orcutt grass is an annual grass which shares some unique characteristics with other grasses in its genus such as stems filled with pith, rather than hollow stems like most grasses. These grasses also grow underwater for 3 months or more and have evolved specific adaptations for both aquatic and terrestrial growth such as producing two or three different types of leaves during their life cycle, whereas most grasses have a single leaf type throughout their life span. Slender Orcutt grass is endemic to vernal pools and occurs primarily on substrates of volcanic origin within a vernal pool ecosystem in northern California (FWS, 2004b). In 2003, FWS designated critical habitat for slender Orcutt grass and several other vernal pool species in its *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (68 FR 46,683 – 46,867). The Klamath Hydroelectric Project is not located within any of the designated critical habitat units for this species and FWS did not identify any critical habitat near the Klamath Hydroelectric Project.

An occurrence of slender Orcutt grass has been reported in Siskiyou County, California, and PacifiCorp suspected that slender Orcutt grass could potentially occur anywhere in the project vicinity from Keno Canyon to the Iron Gate development. However, no slender Orcutt grass was observed during PacifiCorp's field surveys, nor were any vernal pools documented within the area influenced by project operations. Also, the Klamath Hydroelectric Project does not occur in any of the vernal pool regions identified in the FWS recovery plan that includes this species, and no critical habitat for this species occurs in the project vicinity. For these reasons, we do not discuss this species further in this document.

3.3.5.1.6 Applegate's Milk-vetch

FWS listed Applegate's milk-vetch (*Astragalus applegatei)* as an endangered species on June 28, 1993. Applegate's milk-vetch is a perennial legume that was believed to be extinct until its rediscovery in 1983. The species is endemic to the Lower Klamath Basin and is restricted to flat-lying, seasonally moist, strongly alkaline soils. Applegate's milk-vetch has previously been found in only three sites, all situated at about elevation 4,100 feet in Klamath County, Oregon. These three sites are Ewauna Flat, near Keno reservoir at the southern edge of the city of Klamath Falls, where the largest population is located, the Klamath Wildlife Area, about 6 miles southwest of Klamath Falls, near the town of Midland, and, within the vicinity of Worden, Oregon, approximately 3 miles north of the California border. The floodplains where Applegate's milk-vetch is found are noticeably moist in the winter and spring, which may partially be caused by the clay hardpans underlying the known sites for Applegate's milk-vetch. Hardpans impede water percolation, providing seasonal soil moisture saturation and retention. Applegate's milk-vetch has likely adapted to, and may require, this hydrologic regime since the excessive soil moisture may exclude plants requiring dry conditions, creating a niche for this species (FWS, 1998b).

The Nature Conservancy purchased nearly 7 acres of land that encompasses much of the Ewauna Flat population of Applegate's milk-vetch (FWS, 1998b). Fencing has been placed around this milk-vetch population, and the current ownership should protect it from encroaching development.

During field surveys, PacifiCorp discovered a new occurrence of Applegate's milk-vetch along Keno reservoir. PacifiCorp observed 50 to 60 Applegate's milk-vetch plants within 45 to 100 feet of Keno reservoir along approximately 250 feet of the reservoir shoreline. PacifiCorp estimated that the height or elevation of the site above the reservoir water surface was less than 2 feet. PacifiCorp reported that this site was dominated by gray rabbitbrush and saltgrass.

3.3.5.1.7 Gentner's Fritillaria

FWS listed Gentner's fritillaria (*Fritillaria gentneri)* as an endangered species on December 10, 1999. Gentner's fritillaria is a perennial member of the lily family (Liliaceae) and has showy, deep red to maroon flowers from April until July. Gentner's fritillaria occurs primarily in the rural foothills of the

Rogue and Illinois River valleys in Jackson and Josephine counties, Oregon at elevations ranging from approximately 1,004 to 5,064 feet. A small population is also located in northern California, close to the Oregon border. The species is often found in grassland and chaparral habitats within, or on the edge of, dry, open woodlands (FWS, 2003).

PacifiCorp determined that Gentner's fritillaria could potentially occur anywhere in the project vicinity from the J.C. Boyle reservoir to the Fall Creek development, since this area is located in recovery unit 4 designated in FWS recovery plan for this species. No Gentner's fritillaria were observed during the field surveys.

3.3.5.1.8 California Red-legged Frog

FWS listed the California red-legged frog (*Rana aurora draytoni)* as a threatened species on June 24, 1996. Cal Fish & Game lists this species as a Species of Special Concern, which includes species not listed under the California Endangered Species Act, but believed by Cal Fish & Game to either be declining at a rate that could result in listing, or historically occurring in low numbers and having current known threats to their persistence. On March 13, 2001, FWS formally designated critical habitat for this species. None of the Klamath Hydroelectric Project was included in any of the critical habitat units. However, on June 8, 2001, a lawsuit challenging the designation was filed in the U.S. District Court for the District of Columbia, and on November 6, 2002, the court entered a consent decree remanding the designation to FWS and vacating most of the 2001 designation. On April 13, 2004, FWS proposed designating critical habitat for the CRLF identical to the configuration of the previously published final designation of critical habitat and accepted comments on this proposal until July 14, 2004. On November 3, 2005, FWS revised the critical habitat boundaries to better reflect lands containing essential features for the California red-legged frog, and proposed designating approximately 737,912 acres of critical habitat in 23 California counties. FWS accepted comments on this proposal until February 1, 2006. Siskiyou County is not one of the counties containing the proposed critical habitat. FWS did not designate any critical habitat in Oregon.

The California red-legged frog is the largest native frog in the western United States and is typically associated with deep, still, or slow moving water and dense, shrubby or emergent vegetation (FWS, 2002b). The Klamath Hydroelectric Project is not located within or near the current or historic range of the California red-legged frog. PacifiCorp did not observe any California red-legged frogs during the field surveys. The Klamath Hydroelectric Project is not located in or near any of the recovery units designated by FWS in its recovery plan for this species and no critical habitat for this species occurs in the project vicinity. For these reasons, we do not discuss this species further in this document.

3.3.5.1.9 Bald Eagle

FWS listed the bald eagle (*Haliaeetus leucocephalus*) as an endangered species on March 11, 1967, and then reclassified it to threatened status on July 12, 1995. Populations have continued to thrive, and on July 9, 2007, FWS announced its decision to remove the bald eagle from the list of threatened and endangered species, effective August 8, 2007 (FWS, 2007). FWS will work with other federal agencies, tribes, and the states to monitor bald eagle populations at 5-year intervals over a 20-year period after de-listing, and could re-list the species, if results indicate it is again in need of ESA protection.[116]

The largest known wintering population of bald eagles in the contiguous United States occurs in the Klamath basin. In some years, up to 117 bald eagle pairs nest and 1,100 individuals winter in the

[116]Bald eagles are still protected under the Bald and Golden Eagle Protection Act and Migratory Bird Treat Act. These laws will continue to provide protection for the bald eagle at the federal level when it is removed from listing under the ESA. State laws will also continue to provide protection in California and Oregon, where the bald eagle is listed as endangered and threatened, respectively.

Klamath basin. A large communal roost is located south of Klamath Falls, Oregon, in the Bear Valley National Wildlife Refuge west of Worden, Oregon. The refuge is about 6 miles south of Keno reservoir.

The Klamath Hydroelectric Project is located in the Klamath Basin and California/Oregon Coast management zones identified in the Bald Eagle Recovery Plan for the Pacific Region (FWS, 1986). Overall recovery goals for the bald eagle in the Pacific Region were met in 1990 and have been reached or exceeded in every year since. Goals for nest productivity and wintering population stability in the region also have been met or exceeded. Although the recovery goal of 800 breeding pairs in the region has not yet been reached, the number of breeding pairs has increased dramatically. In 2000, the Klamath Basin Management Zone had 117 occupied breeding sites, which greatly exceeded its habitat management goal of 80. In the California/Oregon Coast Management Zone the habitat management goal is 52 bald eagle territories and 28 breeding pairs. The nesting season for bald eagles in Oregon generally runs from February through mid-August.

Both nesting resident and migrant bald eagles occur in the vicinity of the Klamath Hydroelectric Project. In 2002, the Oregon Cooperative Fish and Wildlife Research Unit conducted aerial surveys, searched for new nests, and checked 19 previously known nesting territories in the project vicinity, nine of which were not near any project water bodies. In 2003, the Oregon Cooperative Fish and Wildlife Research Unit conducted bald eagle aerial surveys to determine the status of the same 19 nests inspected in 2002. In 2003, during aerial bald eagle surveys a new, inactive nest located approximately 540 feet southeast of Copco dam was discovered. These surveys documented 10 nests, including the newly discovered Copco dam nest, within about 7 miles of the project (table 3-84). Other than the inactive Copco dam nest, only the Moore Park East, Topsy, and Jenny Creek nests are within 1 mile of any project facility. The Pony Express nest is about 7 miles from a facility, but is immediately adjacent to the J.C. Boyle peaking reach. All nests were located in large ponderosa pine trees.

In 2002, eight young fledged from the eight occupied territories. This equates to a production rate of 1.0 fledglings/occupied territory, which is equal to the recovery goal of 1.0 young/occupied territory. In 2003, eight nests were occupied and three were found to fledge young.

The combination of waterfowl, small mammals, and fish in the vicinity of the Klamath Hydroelectric Project provide abundant forage for resident bald eagles, and at times, wintering bald eagles that congregate in the Klamath basin. The J.C. Boyle, Copco, and Iron Gate reservoirs, along with the Klamath River downstream of Iron Gate dam provide large populations of warm water fish species that are known to be species used by bald eagles in the western United States.

Prey remains collected from under the four successful bald eagle nests near the project that were visited in 2002 indicated a varied diet. Waterfowl and gull remains dominated the collected prey items under the Moore Park nest site. This likely indicates that this pair forages on Upper Klamath Lake, which is in direct view from the nest tree. Perch-like fish remains were the only remains found under the Jenny Creek nest site. This nest is located in a remote canyon about 1 mile from Iron Gate reservoir and not much farther from Copco reservoir. These two project reservoirs likely provide foraging habitat for this pair. Prey remains collected at the Black Mountain and Pony Express nest sites were composed entirely of small mammals, tentatively identified as ground squirrels. This varied diet is consistent with other studies that showed bald eagles to be opportunistic feeders. In a 1989 study of the Grizzly Butte bald eagle territory that occurs in the J.C. Boyle peaking reach, prey brought to the nest included 68 percent fish and 32 percent mammals, which is consistent with the varied and opportunistic diet of bald eagles.

Within the project vicinity, the fish that are available as prey for eagles vary by reach. Fish found in project reaches and reservoirs are described in tables 3-39 through 3-47 in section 3.3.3.1, *Aquatic Resources*. Fish likely to represent potential bald eagle prey include suckers, chubs, rainbow trout, yellow perch, largemouth bass, and sunfish.

Table 3-84. Bald eagle territories and nesting status through 2003 in the general vicinity of the Klamath River Hydroelectric Project. (Source: PacifiCorp, 2004a, as modified by staff)

Nesting Territory Name	Ownership	Nearest Project Facility	Distance to the Nearest Project Facility in feet	First Year Known	Confirmed Young Fledged 1998-2003	Young Fledged in 2002	Young Fledged in 2003
Moore Park East (Oregon)	City of Klamath Falls	West Side canal	4,300	1992	5	2	2
Moore Park/ Wocus Pass (Oregon)	City of Klamath Falls/Private	Link River dam	7,600	1978	7	0	2
Klamath River/ Chase Mtn. (Oregon)	Bureau of Land Management	J.C. Boyle dam	9,300	1979	6	0	0
Topsy (Oregon)	Bureau of Land Management	J.C. Boyle dam	3,900	1998	5	0	0
Klamath River Canyon (Oregon)	Private	J.C. Boyle powerhouse	18,800	1979	4	0	0
Pony Express (Oregon)	Bureau of Land Management	J.C. Boyle powerhouse	37,300	2001	3	3	0
Lucky Springs (California)	Forest Service	Copco dam	27,200	1983	4	Unknown	Inactive[a]
Copco Dam (California)	Private	Copco dam	540	2003	NA	NA	Inactive
Jenny Creek (California)	Bureau of Land Management	Fall Creek canal	3,200	1985	Unknown	2	0
Black Mountain (California)	Federal	Iron Gate dam	30,800	2002	2	1	1

[a] Inactive indicates that no eagles were observed at a nest or within a breeding territory (0 = No young fledged within an "active" breeding territory).

The river reach downstream of Iron Gate dam supports many species of cool water or cold water species that are known to be used by bald eagles, such as chubs, suckers, trout, and salmon. Anadromous salmonids historically and currently using the lower Klamath basin downstream of Iron Gate dam include summer and winter-run steelhead, spring fall Chinook salmon, and coho salmon. One or more of the anadromous fish species/life stages is present in the river downstream of Iron Gate dam during all months of the year (see table 3-37) and annual estimates of adult steelhead and salmon returns to the Klamath River Basin are described in section 3.3.3.1, *Aquatic Resources*. After spawning, most salmon die, and their carcasses represent an important food source for bald eagles.

Data from other river systems (e.g., the Pit River in California) indicate that bald eagles make use of shallow pool tail-outs and runs to forage for fish such as suckers and chubs. It is in these types of habitats that eagles can prey on fish because of increased water clarity and less water turbulence. Aquatic habitat mapping indicates that even during high flows, the J.C. Boyle bypassed and peaking reaches provide 56 to 80 percent pool, glide, and run habitat. From a coarse habitat structure perspective, there should be ample foraging habitat in these river reaches. As discussed in section 3.3.2.1.2, *Water Quality*, water clarity sampling results (turbidity) in the vicinity of the Klamath Hydroelectric project show a seasonal and longitudinal pattern. Generally, water clarity in the Klamath River is reduced during the spring run-off period and is greater in the lower project reaches during the summer and fall months. The Copco No. 2 bypassed reach is too heavily forested to provide foraging habitat for eagles.

Targeted avian field surveys conducted by PacifiCorp in 2002 and 2003 resulted in 37 bald eagle detections. The largest number of bald eagle detections was 11, recorded along the J.C. Boyle reservoir. Eight detections at Copco reservoir accounted for the second highest number of bald eagle records. Bald eagles were also observed perched or flying over J.C. Boyle and Keno reservoirs. There were no obvious concentrations of foraging eagles along project reservoirs or river reaches. However, during February 2003, two adult bald eagles and three subadults were perched along the southern shoreline of Copco reservoir a short distance from Mallard Cove, where they were seen diving on waterfowl. Occasionally, bald eagles were observed perched in oak trees or on power poles near the northwest shore of Copco reservoir. At J.C. Boyle reservoir, bald eagles were documented perching near the shoreline along most of its length.

Bald eagles were also detected by PacifiCorp during goshawk protocol surveys, reservoir surveys, rapid ornithological inventories, and during other project-related field studies. Five bald eagle detections were recorded during northern goshawk protocol surveys with four along the J.C. Boyle reservoir and one in the J.C. Boyle bypassed reach. Eight bald eagles were recorded during reservoir surveys with four near Copco reservoir, one near J.C. Boyle reservoir, and three near Keno reservoir. Bald eagles also were detected during censuses associated with a rapid ornithological inventory conducted in the J.C. Boyle peaking reach. In addition, numerous bald eagle detections were recorded incidental to other field studies in other areas of the project.

No eagle collisions or electrocutions have been reported on project transmission lines since the introduction of PacifiCorp's Raptor Electrocution Reduction Program in the late 1980s.

3.3.5.1.10 Northern Spotted Owl

FWS listed the northern spotted owl (*Strix occidentalis caurina*) as a threatened species on June 26, 1990. Northern spotted owls are one of the largest North American owls, averaging 18 inches tall with a wingspan about 48 inches wide. This species is typically found in old growth forests of northern California and the Pacific Northwest of the United States and in southern parts of British Columbia, Canada. Suitable spotted owl habitat includes old-growth forest areas with multi-layered canopies of trees that are high and open enough for the owls to fly between and underneath them. Spotted owls prefer areas with large trees with broken tops, deformed limbs, and large cavities that are capable of supporting their nesting materials (Defenders of Wildlife, 2005).

In southern Oregon, spotted owls are known to successfully breed in late-successional mixed coniferous forest and several breeding pairs are known to occur in the project vicinity. FWS designated critical habitat for this species on January 15, 1992, and approximately 35,700 acres of designated critical habitat is located north of the Klamath Hydroelectric Project boundary in the Jenny Creek watershed. FWS focused on nesting and roosting habitat as the most important elements of spotted owl habitat when designating critical habitat (57 FR 1,796 -1,836). There are approximately 11,300 acres of potentially suitable spotted owl habitat in the project vicinity, including all forested communities (with the exception of oak woodland and oak-juniper woodland) with at least 40 percent canopy cover and trees greater than 6 inches in diameter. Suitable habitat for the spotted owl occurs within the project boundary at the western end of Keno development, at J.C. Boyle development, along both sides of Shovel Creek, on the south side of Copco reservoir, and at Fall Creek development.

PacifiCorp conducted northern spotted owl protocol surveys during the 2002 and 2003 field seasons in habitat meeting the protocol criteria within 1.2 or 1.3 miles of project facilities and recreation sites that are adjacent to the project reservoirs. In 2002, PacifiCorp recorded five northern spotted owl detections, representing three individuals. PacifiCorp detected one male along the J.C. Boyle peaking reach in June, and one pair along the J.C. Boyle peaking reach in the same general area on 2 days in July. None of the detections were within 5 miles of any project facilities. No incidental spotted owl detections were noted during other field study types in 2002.

In 2003, PacifiCorp again recorded five northern spotted owl detections and presumed that they represented four or five owls. PacifiCorp detected a mixed gender pair of owls southwest of the Beswick Ranch along the J.C. Boyle peaking reach and a lone female owl located about 0.5 mile from the pair described above. This bird may have been the female from the mated pair, although the location of the detection indicated that this may be a separate isolated individual female owl. PacifiCorp also detected two female spotted owls located less than 1 mile southeast of J.C. Boyle reservoir. These two detections were recorded on consecutive evenings and may actually represent a single female spotted owl.

The location of the mixed gender pair of owls detected by PacifiCorp is consistent with that of a historic pair of owls monitored by the Forest Service. The National Council for Air and Stream Improvement also monitors a breeding pair of owls in the upper J.C. Boyle peaking reach. Northern spotted owls have large home ranges and use large tracts of land containing a substantial amount of older forest to meet their biological needs. FWS has determined that northern spotted owls in the Klamath province have home ranges of about 1,000 acres in size (57 FR 1,796 – 1,838). The owl detections made during PacifiCorp field surveys were within the home ranges of the Negro Creek and Lucky Springs pairs that have been monitored by the National Council for Air and Stream Improvement or the Forest Service. Radio telemetry data from this monitoring indicates that these spotted owl pairs have home ranges that do not extend within 0.5 mile of the Klamath River.

3.3.5.1.11 Western Snowy Plover

FWS listed the western snowy plover (*Charadrius alexandrinus nivosus)* as a threatened species on March 5, 1993 (FWS, 2001b). The Oregon Fish and Wildlife Commission lists this species as threatened; the Oregon Natural Heritage Information Center includes it on its List 2, which includes species that are threatened with extirpation or presumed to be extirpated from the state of Oregon; and Cal Fish & Game lists this species as a Second Priority Species of Special Concern, which includes species that are definitely jeopardized and declining, but extinction or extirpation appears less imminent than species with a higher priority. The western snowy plover is a shorebird that typically nests in sandy substrate along the Pacific Coast from southern Washington to southern Baja California, Mexico. However, a small inland population, consisting of less than 1,000 birds in Oregon, is known to nest along the margin of alkaline lakes in southern Klamath County, Oregon, and the species is a rare fall migrant at the Klamath Wildlife Area. PacifiCorp did not locate any western snowy plovers during field surveys and

no suitable breeding habitat was observed in the project area. For these reasons, we do not discuss this species further in this document.

3.3.5.1.12 Canada Lynx

FWS listed the Canada lynx (*Lynx canadensis)* as a threatened species on March 24, 2000 and the Oregon Natural Heritage Information Center includes it on its List 2. Lynx are solitary, boreal forest felines with a northern range extending south along the west coast to southern Oregon. They have large feet adapted to walking on snow, long legs, tufts on the ears, and black-tipped tails. Lynx are highly adapted for hunting snowshoe hare, their primary prey, in the snows of the boreal forest. In the United States, lynx inhabit conifer and conifer-hardwood habitats that support their primary prey, snowshoe hares. In North America, the distribution of lynx is nearly the same as that of snowshoe hares; lynx survivorship, productivity, and population dynamics are closely related to snowshoe hare density in all parts of its range (FWS, 2005). Canada lynx occurrence records in Oregon are uncommon, and the last confirmed specimen was observed in Corvallis in 1974. In its recovery plan, FWS considers the entire state of Oregon to be a "peripheral area" for lynx habitat and occurrence because there is no evidence of long-term presence or reproduction that might indicate colonization or sustained use of the area by lynx and there have been large gaps in time with no lynx sighting records (FWS, 2005).

According to FWS recovery outline for this species, quality and quantity of habitat to support adequate snowshoe hare or lynx populations in this peripheral area are questionable. Habitat may occur in small patches and is not well-connected to larger patches of high quality habitat. PacifiCorp did not observe any Canada lynx during field surveys, nor did it observe any snowshoe hares, the primary prey for lynx. Even though lynx are reported to have large home ranges, and to be highly mobile, it is unlikely that this species would occur in the project vicinity. For these reasons, we do not discuss this species further in this document.

3.3.5.1.13 Gray Wolf

FWS listed the gray wolf (*Canis lupus*) as an endangered species on March 9, 1978 and then reclassified the western distinct population segment, which includes wolves in Oregon and California, to threatened status on April 1, 2003. It is listed as endangered by the Oregon Fish and Wildlife Commission and is on List 2 at the Oregon Natural Heritage Information Center. Key habitat components for wolves are an abundance of natural prey and minimal conflict with human interests and uses (FWS, 1987). Gray wolves typically range in northern areas of tundra and untouched wilderness but wolves have recently been documented in the far northeastern corner of Oregon. PacifiCorp did not locate any gray wolves during field surveys, little suitable habitat exists in the project vicinity, and the Klamath Hydroelectric Project is not included in any of the recovery areas identified in the recovery plan for this species. For these reasons, we do not discuss this species further in this document.

3.3.5.2 Environmental Effects

3.3.5.2.1 General Recommendations

Oregon Fish & Wildlife recommends that if, at any time, unanticipated circumstances or emergency situations arise in which federal or state ESA-listed fish or wildlife are being killed, harmed, or endangered by any project facilities or as a result of project operation, PacifiCorp would immediately take appropriate action to prevent further loss in a manner that does not pose a risk to human life, limb, or property. PacifiCorp would, within 6 hours of any such event, notify appropriate resource agencies and implement restoration actions, as needed. Within 10 days of the event, PacifiCorp would inform the Commission of the nature of the event and restorative measures taken.

Our Analysis

It is reasonable to expect that in response to any type of environmental monitoring, if the need for corrective actions or opportunities for environmental enhancements becomes apparent, recommendations based on the monitoring results would be specified in any monitoring report submitted to the Commission for approval. We consider it most appropriate to include measures that would protect fish and wildlife from identifiable sources of harm as specific conditions of a new license. However, in some instances, unanticipated project-related effects may result in unexpected mortality or injury to fish and wildlife. We conclude that establishing notification procedures to alert the management agencies of project-related fish or wildlife problems and to develop appropriate measures to minimize adverse effects, as Oregon Fish & Wildlife recommends, is both reasonable and appropriate.

3.3.5.2.2 Coho Salmon

NMFS (2002) has identified important coho salmon habitat in the Shasta, Scott, Salmon, and Trinity rivers; in 6 creeks between Iron Gate dam and Seiad Valley; 13 creeks between Seiad Valley and Orleans; and 27 creeks between Orleans and the mouth of the Klamath River. Designated critical habitat within the Klamath basin includes all rivers within accessible reaches including estuarine areas and tributaries, excluding areas on tribal lands and habitat upstream of existing impassable barriers including Iron Gate dam. NMFS identified five essential habitat types for the SONCC coho salmon ESU: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Measures proposed by PacifiCorp and prescribed or recommended by other stakeholders have the potential to affect coho salmon and their critical habitat downstream of Iron Gate dam by affecting sediment transport, water quality, fish disease, instream flows, and fish passage. We evaluate the potential benefits of these measures in *Geology and Soils* (section 3.3.1), *Water Quality* (section 3.3.2.2.2), *Instream Flows* (section 3.3.3.2.1), *Fish Passage* (section 3.3.3.2.2), *Disease Management* (section 3.3.3.2.3), *Dam Removal or Decommissioning* (section 3.3.3.2.4), *Anadromous Fish Restoration* (section 3.3.3.2.5), and *Iron Gate Hatchery Management* (section 3.3.3.2.6). In this section, we summarize the potential effects of these measures on coho salmon and their critical habitat.

Our Analysis

Effects on Critical Habitat

Juvenile summer and winter rearing areas and areas for growth and development to adulthood. Available information indicates that coho salmon in the Klamath basin primarily use tributary habitats for spawning and rearing to the smolt stage. Most coho salmon emigrate from tributaries as age 1+ smolts during March and April, and they migrate through the lower river from May through July.[117] Although some coho salmon fry emigrate from tributaries into the mainstem of the Klamath River, NAS (2003) reports that juvenile coho salmon are uncommon in the mainstem in early summer and become progressively less common as the season progresses. It reports that juvenile coho salmon are virtually absent from the mainstem, including pools at tributary mouths, by late summer. We conclude that this substantial reduction in abundance indicates that few of the fish that emigrate to the mainstem as fry survive to the smolt life stage, or that these fish migrate into coldwater tributaries when water temperatures in the mainstem rise during the summer.

[117]The timing of coho salmon juvenile movement is based on a bar graph showing timing of coho juvenile collections during screw trap sampling conducted in the mainstem Klamath River, Shasta River, and Bogus Creek as presented by Tom Shaw, FWS, at the Lower Klamath Basin Science Conference on June 8, 2004.

Several of the measures proposed by PacifiCorp, recommended by stakeholders, or developed by staff have limited potential to improve rearing habitat for coho salmon in the mainstem Klamath River. These include the development of a temperature management plan, measures to increase downstream dissolved oxygen levels, and to manage the incidence of fish disease. Although there is relatively little information on the effects of fish diseases on coho salmon in the Klamath basin, controlling the incidence of fish disease on the more abundant fall Chinook salmon should limit the potential for transmission of these diseases to coho salmon during their migration through the mainstem Klamath River. We conclude, however, that summer temperatures and competition with juvenile fall Chinook salmon and steelhead would continue to limit the survival of coho salmon that migrate into the mainstem Klamath River as fry.

Measures recommended by Siskiyou County to enhance stream flows and reduce water temperatures in the Shasta River would provide a substantial benefit to coho salmon that spawn and rear in that basin, and would help to reduce water temperatures in the mainstem Klamath River. However, the Klamath Hydroelectric Project does not directly affect habitat conditions in the Shasta River. Nevertheless, we include measures to reduce water temperatures in tributaries such as the Shasta River among the measures that could be considered as part of a disease monitoring and management plan designed to improve conditions in the Klamath River migratory corridor (discussed in section 3.3.3.2.3, *Disease Management*).

Juvenile and adult migration corridors. Adult coho salmon ascend the Klamath River from October through December and migrate through the mainstem river to access and spawn in tributary habitats. As described above, most juvenile coho salmon migrate from tributaries and pass through the mainstem Klamath River between mid-March and early July. Water temperatures during the adult migration period are generally near optimal, but water temperatures often reach stressful to severely stressful levels during the last few weeks of the juvenile migration (see table 3-71).

Effects of proposed and recommended measures on the juvenile migration corridor would be essentially the same as those that we describe previously for effects on rearing habitat. Measures included in our integrated fish passage and disease management program would provide substantial new information on the project's contribution to adverse water quality conditions, microcystin levels, and pathogen concentrations, and would evaluate several possible methods for alleviating water quality and disease-related losses. Although few if any measures would affect conditions during the adult migration period, existing conditions appear to be favorable for coho salmon during that particular period.

Spawning areas. Most coho salmon spawning takes place in tributaries, but coho salmon have been observed spawning in side channels, tributary mouths, and shoreline margins of the mainstem Klamath River between Beaver Creek (RM 161) and Independence Creek (RM 94) (T. Shaw, M. Magnusen, A. Olsen, personal communication, as cited by Trihey & Associates, 1996). Sediment augmentation downstream of Iron Gate dam as proposed by PacifiCorp has the potential to increase the amount of spawning habitat that is available to coho salmon in the mainstem Klamath River. However, because high summer water temperatures appear to limit the survival of coho salmon that attempt to rear in the mainstem Klamath River, any increase in spawning habitat is unlikely to provide an increase in coho salmon production or population sizes, unless rearing coho salmon are able to take refuge in coldwater tributaries.

Consistency with 2002 NMFS BiOp on operation of Reclamation's Klamath Irrigation Project. We conclude that relicensing the project as proposed by PacifiCorp would be consistent with the Reasonable and Prudent Alternative identified in the NMFS 2002 BiOp on Reclamation's operations of the Klamath Irrigation Project. Under PacifiCorp's proposed measure, ramp rates and flow releases downstream of Iron Gate dam would comply with Reclamation's annual operating plans, which Reclamation must develop in compliance with FWS and NMFS BiOps. We note that many of the elements that would be included in an integrated fish passage and disease management program, as described in section 3.3.3.2.5, *Anadromous Fish Restoration*, would provide potential benefits to coho

salmon by: (1) restoring passage to and from Spencer Creek, the tributary that is considered to include the best potential habitat upstream of Iron Gate dam; (2) greatly expanding the available water quality information in the lower Klamath River and its primary tributaries; and (3) greatly expanding available information on the incidence of microcystin and disease pathogens within the migratory corridor downstream of Iron Gate dam, and (4) evaluating potential methods to improve conditions in the migratory corridor, including implementing a spring pulse flow by drawing down Copco and Iron Gate reservoirs to minimum operating pool. This information should assist the Conservation Implementation Program (established under the NMFS Reasonable and Prudent Alternative) with evaluating the potential flow management measures for controlling fish disease and improving the outmigration survival of coho and fall Chinook salmon.

Consistency with the 2004 Cal Fish & Game Coho Recovery Strategy. We conclude PacifiCorp's proposal would assist with implementing four out of 13 watershed recommendations identified in the Cal Fish & Game recovery strategy that pertain to the mainstem Klamath River, and would not hinder the implementation of other recommendations identified in the plan. PacifiCorp's proposal would assist with implementing the following recommendations: *1. Development of an adaptive management plan for low flow emergencies; 5. Applying protective downramping rates at Iron Gate dam; 11. Restoring coarse sediment supply and transport near Iron Gate dam;* and *12. Acquiring additional water for instream flows through conservation easements, purchase and/or transfer of water and water rights from willing sellers.* PacifiCorp measures that would contribute towards these recommendations are measures 2P, 21P, 22P, and 14P (see section 2.2.3, *Proposed Environmental Measures*, for a description of each of these measures). Implementing an integrated fish passage and disease management program as described in section 3.3.3.2.5, *Anadromous Fish Restoration*, would provide critical information on the feasibility of coho salmon passage over project dams and through project reservoirs, on approaches for addressing fish disease problems in the Klamath River downstream of Iron Gate dam, and on the effects of the project on downstream water quality. This would contribute to the following recommendations from the recovery strategy, in addition to the previously listed benefits of PacifiCorp's proposed measures: *3. Conducting a feasibility analysis for coho salmon passage over Iron Gate and Copco dams to access historic habitat; 7. Performing a cost/benefit analysis of full or partial removal of the Klamath Hydroelectric Project dams*; and 10. *Addressing problems relating to water quality, disease, and hatchery operations*. Finally, our analysis indicates that the substantial increases in flows released into the J.C. Boyle bypassed reach recommended by the agencies could adversely affect the size and quality of a large temperature refugia in the bypassed reach, which could play an important role in future salmon restoration efforts. We conclude that implementing the agency-recommended flows would be inconsistent with the following recommendation from the recovery strategy: *9. Studying and protecting temperature refugia*.

Consistency with 2007 NMFS MSRA Klamath River Coho Salmon Recovery Plan. We conclude that the project, as proposed by PacifiCorp, would not contribute towards any of the six high priority recovery actions identified in the MSRA recovery plan. Any alternative that includes the provision of passage to project tributaries (especially to Spencer Creek) via volitional passage, trap and haul passage, or dam removal would contribute directly towards priority action *B: Restore access for coho salmon to the upper Klamath River Basin by providing passage beyond existing mainstem dams*, and would contribute indirectly to priority action *C: Provide incentives for private landowners and water users to cooperate in restoring access to tributary streams that are important for coho spawning and rearing and enhancing mainstem and tributary flows to improve instream habitat conditions*. Because PacifiCorp's proposal does not include any provisions to provide for coho salmon passage to habitat upstream of Iron Gate dam, we conclude that its proposal is inconsistent with these recovery actions. Finally, we note that implementing an integrated fish passage and disease management program would greatly expand the available information on disease incidence and its relationship to flow levels and water quality parameters in the migratory corridor downstream of Iron Gate dam, which would foster the development and implementation of measures for effectively controlling the incidence of fish diseases. This would

contribute towards priority action *F: Implement restorative measures identified through fish disease research results to improve the health of Klamath River coho salmon populations*.

Effects of Fish Passage and Dam Removal

Although no critical habitat has been designated upstream of Iron Gate dam, potential habitat exists within the project area in several of the tributaries to the project reservoirs, and possibly in Shovel Creek, which enters the J.C. Boyle peaking reach. PacifiCorp (2006a) states that Spencer Creek, which flows into J.C. Boyle reservoir, contains abundant spawning habitat and excellent rearing conditions for coho salmon, providing more than three times the amount of rearing habitat, based on low-flow rearing area, than the combined area available in the tributaries between J.C. Boyle and Iron Gate dams (Jenny, Fall, and Shovel creeks). In its Recovery Strategy for California Coho Salmon, Cal Fish & Game (2004b) recommends that a plan, including a feasibility analysis, be developed to provide passage for coho salmon over and above Iron Gate and Copco dams to restore access to historic habitat. NAS (2003) recommends that the benefits to coho salmon from elimination of Dwinnell dam and Iron Gate dam should be evaluated on grounds that these structures block substantial amounts of coho salmon habitat and, in the case of Dwinnell Dam, also degrade downstream habitat.

In sections 3.3.3.2.4, *Dam Removal or Decommissioning*, and 3.3.3.2.5, *Anadromous Fish Restoration*, we evaluate the potential benefits of dam removal and various approaches to restoring anadromous fish passage to habitat within and above the project area. Provision of passage into the reach between Iron Gate and Copco No. 2 dams would provide access to several small tributaries including Fall and Jenny creeks, provision of passage over Copco No. 1 dam would provide access to potential habitat in Long Pine and Shovel creeks, and provision of passage over J.C. Boyle dam would provide access to Spencer Creek.

Implementing the NMFS/Interior fishway prescription would provide volitional upstream and downstream passage at all project dams, and provide access to the tributary habitats identified above. We have serious reservations, however, about the survival rates of outmigrating smolts passing through Copco and Iron Gate reservoirs due to potential losses from fish predation and the cumulative stress from passing through multiple screening facilities, especially when stressful water quality conditions exist during the later part of the outmigration season. We include in the Staff Alternative an integrated fish passage and disease management plan that would take an aggressive approach to restore passage of coho salmon to valuable habitat in Spencer Creek and to address critical uncertainties relating to reservoir passage and effects of the project on adverse water quality conditions and pathogen densities downstream of Iron Gate dam.

Removal of Iron Gate and Copco No. 1 dams would substantially reduce the risk of fish predation on outmigrating smolts. It would also reduce the number of screening facilities that outmigrating smolts would have to negotiate as well as exposure to adverse water quality conditions during the downstream migration period. Because the reservoirs created by the J.C. Boyle and Copco No. 2 dams do not have as large a population of predatory fish and because they have less effect on water quality conditions (due to the smaller volume of the reservoirs), removal of these dams would provide minimal additional benefit if effective fish passage was provided at these dams. However, we conclude that there is insufficient information available to understand the full range of project effects on water quality conditions and the prevalence of fish diseases downstream of the project, which makes it impossible to fully evaluate the potential effects of dam removal. The intensive monitoring and testing of experimental spills and reservoir drawdowns that would be implemented through our integrated fish passage and disease management program would help to fill this gap. This would allow the potential benefits and adverse effects of dam removal to be more fully considered, and evaluation of measures that could be taken to improve conditions in the downstream migratory corridor. We make our final conclusions regarding coho salmon in section 5.6.4, *Endangered Species Act*.

3.3.5.2.3 Lost River and Shortnose Suckers

Lost River and shortnose suckers are known to occur in Upper Klamath Lake and its tributaries; the Lost River; Tule Lake; Clear Lake; and Gerber, J.C. Boyle, Copco, and Iron Gate reservoirs. These species reside primarily in lake habitats and spawn in tributary streams or at springs and shoreline areas within Upper Klamath Lake. Upper Klamath Lake currently supports the largest remaining population of both species.

PacifiCorp proposes to decommission the East Side and West Side facilities to eliminate the entrainment of listed suckers at these developments. FWS recommends that PacifiCorp develop an adaptive management plan for federally listed suckers, in consultation with FWS and Oregon Fish & Wildlife, to evaluate the need for a ladder built to sucker criteria at Keno dam. During the months of February through May, or as otherwise directed by FWS, the anadromous fish trap at that location (part of the fishway prescription for Keno development) would be operated to gather data on the possible need for such a ladder for suckers. Data collected would include information on species, size, sex, and estimated numbers. Regular visual examination also would be conducted to evaluate use of the ladder.

FWS recommends that PacifiCorp develop and implement a plan to monitor resident fish populations every 3 years to include monitoring the distribution, population structure, and abundance of resident fish populations, including federally listed suckers (using protocols of Markle et al. [2000] and Simon et al. [1995], for larvae, juvenile, and adult suckers) in all project reservoirs and reaches below Keno dam.

Our Analysis

Prior to the construction of the Klamath Hydroelectric Project, the Klamath River downstream of Lake Ewauna (now part of Keno reservoir) did not include any lake or reservoir habitat suitable for supporting the rearing life stages of these species. Based on their limited swimming ability compared to salmonid species, it is unlikely that any suckers that moved downstream past the high gradient rapids in the Keno and J.C. Boyle peaking reaches would be able to return upstream to suitable rearing habitat, and they were probably lost from the reproducing population. The project reservoirs, especially the J.C. Boyle, Copco, and Iron Gate reservoirs, provide suitable rearing habitat that did not exist before project construction. Based on the size distribution of the federally listed sucker species that were sampled by Desjardins and Markle (2000), it appears that recruitment to these reservoirs occurs almost entirely through downstream migration of juvenile and adult suckers from Upper Klamath Lake and possibly from J.C. Boyle reservoir. Desjardins and Markle (2000) concluded that the lack of recruitment to Copco and Iron Gate reservoirs was likely due to predation by abundant populations of non-native fish species.

Decommissioning the East Side and West Side facilities, as proposed by PacifiCorp, would eliminate sucker mortality due to entrainment through turbines at these developments, and would increase the recruitment of shortnose and Lost River suckers to the downstream reservoirs. The populations of juvenile and adult suckers in these reservoirs have the potential to play a role in conservation of the species, especially in the event of a catastrophic fish kill in Upper Klamath Lake, as adult fish residing in the project reservoirs could serve as a source of broodstock in a restoration effort.

We see very little potential benefit in evaluating the need for a ladder built to sucker criteria at Keno dam, as FWS recommends. Review of the gradient profile of the Klamath River (see figure 3-1) indicates that the stream gradient in the Keno reach is comparable to the gradient in the Hells Corner section of the peaking reach, which we conclude may preclude the upstream emigration of some sucker species. Furthermore, any suckers that were to ascend a ladder at Keno dam would be subject to lethal DO conditions if they remained in the reservoir during the summer months. We conclude that construction of a fish ladder designed to meet sucker criteria at Keno dam would provide little, if any, conservation benefit to the population of shortnose or Lost River suckers.

Also, we see little reason to expect that sucker populations in project reservoirs would be affected by any proposed measures or changes in project operation, except if downstream recruitment from Upper Klamath Lake were reduced through the installation of a smolt collection or screening facility. Any changes in population structure related to measures implemented in a new license could probably be detected within three monitoring cycles, and we conclude that re-evaluating the frequency of population monitoring efforts in 10 years would be appropriate. We make our final conclusions regarding Lost River and shortnose suckers in section 5.6.4, *Endangered Species Act*.

We also conclude that the project as proposed by PacifiCorp would be consistent with the measures specified in the Reasonable and Prudent Alternative of the 2002 FWS BiOp on operation of Reclamation's Klamath Irrigation Project. The only measure specified in the BiOp that relates to the operation of PacifiCorp's Klamath Hydroelectric Project is the implementation of entrainment reduction measures at Link River dam. Decommissioning of the East Side and West Side developments would eliminate entrainment and all sources of mortality associated with the developments.

We conclude that the project, as proposed by PacifiCorp, would be consistent with all relevant actions identified in the 1993 FWS sucker recovery plan. Any alternatives that include the removal of Iron Gate, Copco No. 1, or J.C. Boyle dams, however, would eliminate sucker habitat and populations in associated reservoirs, and would conflict with actions relating to conserving the genetic diversity of and increasing the size of sucker populations of Lost River and shortnose suckers. Any alternatives that include the installation of fish screens at project intakes could reduce the exposure of juvenile and suckers to mortality caused during passage through project turbines, but could cause impingement-related mortality at the screening facility, especially of larval suckers. As a result, installing fish screens could have variable effects on the recruitment of larval and juvenile suckers to downstream reservoirs. Any alternatives that include monitoring of fish populations and water quality conditions in the project reservoirs would contribute to numerous monitoring-related actions that are included in the recovery plan.

In 2007, FWS completed 5-year reviews on the status of shortnose and Lost River suckers. Future actions identified in these reviews consist of investigating methods to improve recruitment in Upper Klamath Lake, development of a new recovery plan, monitoring of sucker populations in Clear Lake, and investigation of hybridization of shortnose sucker with other sucker species in the Lost River sub-basin. None of the measures that are evaluated in this EIS are expected to contribute to or impede these actions.

3.3.5.2.4 Bull Trout

PacifiCorp does not propose any measures that are designed to benefit bull trout, nor has any agency proposed any specific measures to benefit bull trout. However, implementation of the NMFS/Interior fishway prescription, PacifiCorp's alternative prescription, or restoration of passage of anadromous fish to Upper Klamath Lake via dam removal all have the potential to affect bull trout populations upstream of Upper Klamath Lake.

Our Analysis

All designated bull trout critical habitat in the Klamath basin occurs in the upper basin upstream of Upper Klamath Lake. None of this habitat is affected by the existence or operation of the Klamath Hydroelectric Project, and no bull trout have been reported to occur downstream of Upper Klamath Lake.

Implementation of the NMFS/Interior fishway prescription, PacifiCorp's alternative prescription, or removal of all project dams as recommended by some stakeholders could restore the passage of anadromous fish to Upper Klamath Lake. This has the potential to benefit bull trout populations by increasing opportunities for bull trout by providing access to eggs, fry, and juvenile anadromous fish, upon which bull trout are known to feed. It also has the potential to adversely affect bull trout by introducing or increasing the prevalence of disease pathogens. However, most populations of bull trout in

the basin occur in isolated portions of headwater streams that would not likely be accessible to anadromous fish in the foreseeable future. The only exception to this would be Agency Lake, which is directly connected to Upper Klamath Lake and includes tributaries such as the Wood River that may currently be suitable for the reintroduction of anadromous fish. We make our final conclusions regarding bull trout in section 5.6.4, *Endangered Species Act*.

3.3.5.2.5 Applegate's Milk-vetch

The federally endangered Applegate's milk-vetch was discovered during relicensing surveys within 45 to 100 feet of Keno reservoir. This site is approximately 2 feet above the surface water elevation and, as such, could potentially be affected by reservoir water level fluctuations.

PacifiCorp proposes to remove Keno development from the project boundary. Therefore, the proposed threatened, endangered, and sensitive plant protection measures contained in its vegetation resource management plan (see section 3.3.4.2, *Terrestrial Resources*) would not apply to this population.

Our Analysis

Keno reservoir maintains a relatively stable surface water elevation, as seen in figure 3-8 in section 3.3.2.1.1, *Water Quantity*, with a +/- 0.1-foot fluctuation. The period of record shown in figure 3-8 (1990 through 2004) included several high flow events as measured at the USGS gage downstream of Keno dam, yet the water level of Keno reservoir never increased more than about 6 inches. Any such increases in water level in response to flood conditions would generally not be within the control of Keno dam. As such, the population of Applegate's milk-vetch located about 2 feet above the surface water elevation would not be affected by project operations of Keno dam. Occasional 2-foot maintenance drawdowns occur, which could result in altered hydrology for the plant population; however, these drawdowns generally occur outside of the growing season and are very short in duration. Therefore, project operations of Keno dam would have negligible effects on the Applegate's milk-vetch.

Most of the land occupied by the Ewauna Flats population of Applegate's milk-vetch, adjacent to the Keno reservoir, is owned by the Nature Conservancy, and this organization is taking appropriate stewardship measures to ensure the protection of this population. Although no ground-disturbing activities are currently proposed within the existing project boundary around Keno reservoir, if the reservoir remains within the project boundary, extending PacifiCorp's proposed plant protection measures to the Keno reservoir would protect this population from future project-related, ground-disturbing activities. If Keno development should remain part of the project, no planned operation or maintenance actions would have the potential to affect the known Applegate's milk-vetch populations.

Applegate's milk-vetch is adapted to and may require seasonally moist floodplains (FWS, 1998). We do not have sufficient information to determine if seasonal moistness of the habitat adjacent to Keno reservoir is derived from retention of precipitation on hardpan or whether there may be some hydrological connection with Keno reservoir. If the latter, removal of Keno dam could adversely affect Applegate's milk-vetch by altering the hydrology in the floodplain adjacent to the existing Keno reservoir. We make our final conclusions regarding Applegate's milk-vetch in section 5.6.4, *Endangered Species Act*.

3.3.5.2.6 Gentner's Fritillaria

Although the federally endangered Gentner's fritillaria was not located within the project boundary during relicensing surveys, it could potentially occur anywhere in the project vicinity from the J.C. Boyle reservoir to Fall Creek development, since this area is located in recovery unit 4, as designated in its FWS recovery plan.

PacifiCorp, as part of its vegetation resources management plan described in section 3.3.4.2, *Terrestrial Resources*, proposes to protect, monitor, and adapt management as necessary at known

threatened, endangered, and sensitive plant sites, as well as any new locations identified within the project boundary. In addition, it proposes to coordinate with the transmission and delivery group to provide avoidance training, procedures, and scheduling to avoid or protect threatened, endangered, and sensitive plant sites in or near rights-of-ways. As part of its proposed wildlife resources management plan, PacifiCorp also proposes to conduct on-the-ground surveys for threatened, endangered, and sensitive plant and wildlife species. Based upon the results of these surveys, a site-specific protection plan would be developed in consultation with the resource agencies.

The Bureau of Land Management specifies that PacifiCorp develop a vegetation resources management plan within 1 year of license issuance that includes provisions for managing threatened, endangered, and sensitive plants on Bureau of Land Management-administered lands affected by the project. The plan would include surveys, protection, remediation of effects, and review of rare plant records (see section 3.3.4.2, *Terrestrial Resources*). Oregon Fish & Wildlife's recommendation described previously for Applegate's milk-vetch also would apply to Gentner's fritillaria.

Our Analysis

Because Gentner's fritillaria is not currently known to exist within the project boundary, there are no known project effects on this species. PacifiCorp's proposed threatened, endangered, and sensitive plant protection and monitoring measures would ensure that if any populations are discovered within the project boundary, they would be monitored and protected from potential adverse effects. Because PacifiCorp conducted rare plant surveys during relicensing efforts and proposes to conduct surveys prior to ground-disturbing activities, we conclude that the Bureau of Land Management's specification to conduct additional rare plant surveys on all Bureau land affected by the project is unnecessary for the protection of Gentner's fritillaria.

Because Gentner's fritillaria is not known to exist in the project boundary, dam removal would not affect this species. We make our final conclusions regarding Gentner's fritillaria in section 5.6.4, *Endangered Species Act*.

3.3.5.2.7 Bald Eagle

There are 10 known bald eagle nest sites within approximately 7 miles of the project. Of these, only three active and one inactive nest sites are within 1 mile of any project facility, with none within the project boundary. An additional nest site, the Pony Express nest, is approximately 7 miles from a facility, but is immediately adjacent to the J.C. Boyle peaking reach. Although nesting territories in the project vicinity are meeting the recovery goal of 1.0 young/occupied territory, project operations and associated activities could potentially affect the bald eagle. Specifically, bald eagles could potentially be affected by collisions with project transmission lines, disturbance from project recreation, and the effect of project operations on prey availability.

As part of its proposed wildlife habitat management plan, PacifiCorp proposes to fund annual aerial bald eagle surveys to document new nests and productivity of territories, and to protect bald eagle habitat within the project boundary. The annual data would be used as a monitoring tool in assessing the need for additional environmental measures, such as protection of any newly discovered nest sites within the project boundary. In coordination with its proposed vegetation resource management plan, discussed in section 3.3.4.2, *Terrestrial Resources*, PacifiCorp would preserve existing trees and human-made structures within the project boundary that could be used as perch or roost sites. Additionally, as described in section 3.3.4.2, *Terrestrial Resources*, PacifiCorp proposes to monitor powerlines within the project boundary and, whenever feasible, retrofit poles on lines where birds have died to improve avian protection. PacifiCorp also proposes to conduct on-the-ground surveys for threatened, endangered, and sensitive plant and wildlife species in areas where ground-disturbing activities are proposed.

The Bureau of Land Management specifies that PacifiCorp develop and implement, within 2 years of license issuance, a wildlife habitat management plan for Bureau-administered lands affected by project operations and maintenance. As part of this plan, the Bureau specifies that it include (1) survey protocols for long-term survey and monitoring of threatened, endangered, and sensitive species and their habitat for Bureau-administered lands within the project boundary to assess effects and develop necessary mitigation to supplement the previous surveys completed by PacifiCorp; (2) the identification of restoration, protection, and/or enhancement measures; and, (3) seasonal restrictions for active nest sites on Bureau- administered lands for bald eagles and other raptors affected by project operations.

FWS recommends that PacifiCorp, within 2 years of license issuance, in consultation with FWS and appropriate state and federal land management agencies, develop and implement a bald eagle management plan for the project area. The plan would provide for monitoring and protection of bald eagle nest sites, roost sites, and regular foraging areas from human disturbance. The plan would be based on FWS's Draft Bald Eagle Management Guidelines (FWS, 2006b) or on the successor to those guidelines and would incorporate local knowledge as available. The plan would also include measures for evaluation of changes in prey base relationships and incorporate measures that would protect bald eagles from powerline collisions and electrocution. FWS and Oregon Fish & Wildlife both make recommendations regarding avian protection from potential transmission line interactions and associated monitoring. These measures are discussed in greater detail in section 3.3.4.2, *Terrestrial Resources*.

Our Analysis

Bald eagles are found throughout the project boundary with bald eagle use documented by PacifiCorp on each of the reservoirs, the J.C. Boyle peaking reach, and downstream of Iron Gate dam during both nesting and wintering seasons. Human disturbance to bald eagles can adversely affect their ability to successfully fledge young. Although there are no bald eagle nest sites within the project boundary, project-related human disturbance, particularly from recreation, could deter bald eagles from foraging, if such disturbance is not managed with eagles in mind. Depending upon the tolerance of the eagles to human presence, bald eagles may not use areas that are actively being used by humans during peak feeding times (mid-morning and afternoon). Recreational activities, including boating and camping, are anticipated to increase under a new license, as discussed in section 3.3.6, *Recreation Resources*, particularly at project reservoirs during April through September. Specifically, flatwater boating, angling, and camping occur at the project reservoirs from May through September, and commercial rafting occurs in the peaking reach from April through October. This overlaps with the bald eagle nesting period of February through mid-August. If increased recreation occurs in active bald eagle foraging areas, bald eagles may be disturbed by humans and have to expend additional energy during foraging attempts to locate a place they are willing to inhabit. PacifiCorp proposes monitoring and protection measures that would document any new nests, preserve roosting and perching trees, and monitor productivity of known nests to determine if any further environmental protection measures are needed. These proposals, when implemented as part of a bald eagle management plan, such as the one recommended by FWS, would ensure that increased recreation is not adversely affecting eagles. If productivity is found to be adversely affected by project-related activities, then PacifiCorp's proposed measures and FWS's recommended management plan would provide a mechanism to implement further protective measures, including recreation closures during nesting season.

During nesting season, bald eagles are sensitive to disturbance such as human activity or loud noises too close to their nests. Bald eagle productivity can be adversely affected because of added energy expenditure or even nest abandonment if disturbance is too great. As part of FWS's recommended bald eagle management plan and the Bureau of Land Management's specified wildlife habitat management plan, existing nesting territories would be protected from project management activities, such as major maintenance and vegetation management, during sensitive nesting periods, by closing sensitive areas around nest sites during the nesting season. Four of the active nest sites in the general vicinity of the

project are located on lands managed by the Bureau of Land Management, and the Bureau has indicated that it would seasonally restrict activities in the vicinity of these nests. One other active nest site is located on federal land, and we anticipate that FWS would restrict activities at that site. The other three active nest sites are on lands either owned by the city of Klamath Falls or are in private ownership, and we anticipate obtaining agreements with the city and private landowner(s) to restrict activities at these nest sites may be possible. Within the project boundary, PacifiCorp would protect portions of existing nesting territories from project-related recreation or management activities during sensitive nesting periods. Prohibiting potentially disturbing activities around bald eagle nests would limit or stop bald eagles from leaving their nests in response to human activities. Furthermore, implementing PacifiCorp's proposed and the Bureau of Land Management's specified measures to conduct surveys for threatened, endangered, and sensitive species before ground-disturbing activities would ensure that no new bald eagle nest locations would be disturbed.

As discussed in section 3.3.4.2, *Terrestrial Resources*, PacifiCorp has previously retrofitted most project transmission lines to raptor-safe standards; however, Line 15 still has a few poles that do not meet current safety standards. Line 15 is located south of the Copco No. 2 bypassed reach and has both transmission and distribution lines on the same poles with separation between phases not always more than 60 inches (the suggested minimum distance). Only one nest location, which is inactive, located about 540 feet southeast of Copco No. 1 dam is in the vicinity of Line 15. Although no avian electrocutions have been identified at Line 15, it is located on a north-facing hillside, so it could possibly be a hazard to raptors. According to APLIC (1994), waterfowl and large wading birds are the species most likely to collide with transmission lines because of their lack of maneuverability in flight; therefore, bald eagles are expected to have a low risk of collision. There have been no reported electrocutions or avian collision deaths along the project transmission lines since PacifiCorp personnel began tracking them in the late 1980s.

The *Avian Protection Plan Guidelines* (APLIC, 2005), used in conjunction with *Suggested Practices for Raptor Safety on Power Lines: The State of the Art in 1996* (APLIC, 1996) and *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994* (APLIC, 1994), are considered industry standards for raptor protection from transmission lines. As such, following standards specified in these documents when designing any new poles or retrofitting any existing pole that is involved in avian mortality, as proposed by PacifiCorp and recommended by FWS and Oregon Fish & Wildlife, would minimize the potential for future bald eagle mortality and injury due to collision or electrocution. Developing and implementing an avian collision and electrocution hazard avoidance plan, as recommended by FWS, in consultation with FWS, Oregon Fish & Wildlife, the Bureau of Land Management, and the Forest Service would ensure that appropriate site-specific practices would be put into place for the project's transmission lines, further reducing potential adverse effects on bald eagles. We expect that during the consultation process, FWS and Oregon Fish & Wildlife would ensure that the appropriate provisions of the existing Avian Protection Plan for the Klamath Basin (PacifiCorp and FWS, 2005, as cited in a letter from Interior dated March 27, 2006) would be incorporated into the plan. In addition, such consultation with FWS and Oregon Fish & Wildlife could ensure that provisions for monitoring and reporting avian mortality, as appear to be specified in the 1988 Memorandum of Understanding between PacifiCorp, FWS, and Oregon Fish & Wildlife, would be appropriately addressed. However, because the 1988 Memorandum of Understanding has not been filed as part of this proceeding, we cannot evaluate it further. Bald eagle protection measures, as specified by the Bureau of Land Management and recommended by FWS, would provide mechanisms to limit periodic vegetation control in transmission line rights-of-way that occur within proximity to bald eagle nests to outside of nesting season.

The proposed project could potentially be beneficial to the bald eagle by enhancing its prey base. Currently, bald eagles in the project area have a varied diet that includes waterfowl, mammals, and fish. As described in section 3.3.3.2, *Aquatic Resources*, several measures could result in increased salmonid

populations. PacifiCorp's alternative fishway prescription, which would entail trapping adult salmon at Iron Gate dam and hauling them to appropriate spawning sites could result in more juvenile salmon outmigrating through portions of the project area, and enhancements to the project flow regime proposed by PacifiCorp and recommended by others would likely result in an increase in the resident rainbow trout population. Furthermore, fishway prescriptions, if implemented, could result in adult salmon occurring throughout the project area. However, as discussed in detail in the following section, activities associated with fishway construction could result in disturbance of nearby bald eagle populations, especially during the breeding and nesting season. Fishway construction would be especially prolonged at the two Copco developments and at Iron Gate development.

Removal of all the project dams would result in a change from lacustrine to riverine conditions throughout the project area. As bald eagles frequently forage in lakes and reservoirs, this would eliminate a large amount of bald eagle habitat. Because the areas in proximity to the Fall Creek and Copco No. 2 developments are too heavily forested to provide foraging opportunities for eagles, dam removal would be unlikely to adversely affect bald eagles at those locations. There are no known bald eagle nests in the vicinity of Keno dam, and because much of Keno reservoir is relatively narrow and therefore not ideal foraging habitat, dam removal would be unlikely to affect bald eagles at this location. There are two known eagle nests in the vicinity of the J.C. Boyle reservoir and one known nest territory in the vicinity of Iron Gate dam. It is likely that dam removal at these locations would alter and potentially diminish bald eagle foraging habitat because the broad expanses of open water (preferred foraging habitat) associated with these two reservoirs would be eliminated. Dam removal, if it should occur, would be considered under a separate proceeding (either a license amendment proceeding or, if all project dams should be removed, a project license surrender proceeding), and as such, separate agency consultation regarding measures that may be needed to protect bald eagles, if any, would occur during that proceeding.

3.3.5.2.8 Northern Spotted Owl

Suitable habitat for the federally threatened northern spotted owl occurs within the project boundary at the western end of Keno development, at the J.C. Boyle development, along both sides of Shovel Creek, on the south side of Copco reservoir, and at the Fall Creek development. Surveys conducted by PacifiCorp detected the presence of northern spotted owls near the J.C. Boyle peaking reach, but not within 5 miles of any project facilities. If project-related recreation or new recreational facility development occurred near northern spotted owl nests, it could potentially affect spotted owls.

Although PacifiCorp and the resource agencies did not propose, recommend, or specify any measures specifically for the northern spotted owl, PacifiCorp proposes to conduct surveys for threatened, endangered, and sensitive species prior to any ground-disturbing activities. As previously discussed, PacifiCorp also proposes and FWS and Oregon Fish & Wildlife recommend avian protection measures regarding transmission line interactions, and the Bureau of Land Management specifies that threatened, endangered, and sensitive species surveys and monitoring be conducted and seasonal restrictions of management activities take place on or adjacent to Bureau lands when sensitive avian species could be disturbed. Interior, in its March 27, 2006, letter to the Commission stated that: "Ordinary project operations are not expected to affect this species (northern spotted owl). Activities related to potential construction of fish passage facilities will be subject to section 7 consultation under ESA; the necessity of protection measures will be evaluated at that time. No further measures are proposed herein."

Our Analysis

Although northern spotted owls are known to exist near the project at the J.C. Boyle peaking reach, they are not known to nest within proximity to project facilities. As such, proposed project operations or project-related activities are not expected to affect the owls. No new recreational facility developments are proposed for areas near northern spotted owl nests, and PacifiCorp's proposal to conduct surveys for threatened, endangered, and sensitive species prior to any ground-disturbing activities

would ensure that no new owl nests would be disturbed. PacifiCorp does not propose new fish passage facilities, although relatively minor improvements to existing facilities at J.C. Boyle are proposed.

NMFS and Interior prescribe fishways at all project dams. Construction activities could disturb northern spotted owls. Given the presence of suitable habitat near Keno dam, if this habitat should be occupied when fishways are constructed, the associated disturbance could adversely affect spotted owls if it occurs during the breeding and nesting season. Prescribed fishways at this location include modifications to the existing ladder (with the potential for constructing a new ladder designed for suckers) including a trap and haul facility and spillway modifications. It may be feasible to schedule this activity during periods that would not disturb northern spotted owls, if they occupy nearby habitat. Fishway construction at Copco No. 1 dam could also adversely affect northern spotted owls, if they should occupy nearby suitable habitat near Copco reservoir. Copco No. 1 dam is 126-feet-high, and construction of a fish ladder at this site, scheduled to be completed within 6 years of license issuance, would be a major undertaking. Retrofitting the dam with screens and a bypassed system that would extend to the base of Copco No.2 dam, also scheduled to be completed within 6 years of license issuance, also would require a major construction effort. Spillway modifications, to be completed within 8 years of license issuance, could entail a major construction effort, depending on the modifications that may be needed.

Consequently, there could be at least 3 or 4 years of continuous construction activity and associated construction vehicle traffic on access roads, which would likely disturb northern spotted owls, if they should colonize the nearby suitable habitat. Such extended construction activity would likely preclude colonization of the nearby suitable owl habitat until after completion of construction. Construction of the prescribed fishways at Copco No. 2 dam would occur during the same time frame, and although construction would not be as extensive and undertaking as at Copco No. 1 dam because the dam is only 33-feet-high, potential disturbance of northern spotted owls or owl habitat would occur during on-site construction activities and construction traffic, which would use many of the same roads needed to access Copco No. 1 dam. Fishway construction at Iron Gate dam would entail a similar major construction effort, but the absence of nearby suitable northern spotted owl habitat would likely result in no effect on owls at this location. Fishway construction at J.C. Boyle dam would entail a moderate level of construction activity, but there is no known nearby suitable northern spotted owl habitat, so there would be no identifiable effects on northern spotted owl or its habitat at this site. Fishway construction at the Fall Creek and Spring diversion dams would entail a relatively minor construction effort that would be unlikely to influence northern spotted owl or its habitat.

Construction activities associated with dam removal have the potential to disturb northern spotted owls, depending on the specific dam removed. The potential for disturbance of northern spotted owl or its habitat would be similar to that described for fishway construction, with the greatest potential for long-term disturbance occurring with the removal of Copco No. 1 dam. Similar levels of construction activity would be necessary for removal of Keno and Copco No. 2 dams, which are 25- and 33-feet-high, respectively. Because all three of these dams are near suitable northern spotted owl habitat, removal of each has the potential to affect this species. Removal of J.C. Boyle, Iron Gate, and the two Fall Creek diversion dams would be unlikely to influence northern spotted owls. Dam removal would entail a separate proceeding, as mentioned in the previous section, and section 7 consultation would need to occur as part of that proceeding, reflecting the specific dams that would be slated for removal. We make our final conclusions regarding the northern spotted owl in section 5.6.4, *Endangered Species Act*.

3.3.5.3 Cumulative Effects

3.3.5.3.1 Coho Salmon

The settlement and development of the Klamath River Basin has caused substantial adverse cumulative effects on the habitat and population size of coho salmon. Dams for impounding water for mining and farming operations were first built in the 1850s, and water uses associated with mining

activities caused substantial increases in turbidity, siltation, and altering stream morphology. Starting around 1912, construction and operation of facilities associated with Reclamation's Klamath Irrigation Project resulted in extensive draining of wetlands, increased agricultural diversions, increased nutrient loading, and reduced dissolved oxygen levels. In the 1920s, the water resources in the Shasta and Scott rivers were developed to support irrigated agriculture, and the construction of Dwinnell dam blocked access for coho salmon to the southern headwaters. Agricultural diversions in these tributaries and in the tributaries to Upper Klamath Lake have reduced flows, increased water temperatures, and increased nutrient inputs. Diversion of up to 80 percent of the flow from the Trinity basin to support agriculture in the Sacramento River Basin started in 1964 with the completion of Trinity and Lewiston dams.

Timber harvest practices and grazing have also contributed to erosion, damage to riparian habitat, and increased water temperatures. Overfishing also contributed to the decline of coho salmon in the basin, although NMFS (2002) indicates that fishing mortality has been reduced substantially since the retention of naturally produced coho salmon south of Cape Falcon, Oregon, was prohibited in 1994. Competition with Chinook and coho salmon produced at Iron Gate and the Trinity River hatcheries has also adversely affected wild runs of coho salmon. NMFS (2002) reports that approximately 95 percent of the coho salmon run in the Trinity River above Willow Creek and about 65 percent of the coho salmon run in the Klamath River above Weitchipek consist of hatchery fish. Prior to the construction of Iron Gate dam in 1964, peaking operations at the Copco developments adversely affected anadromous fish by causing large daily fluctuations in flow, which likely resulted in extensive fish stranding.

The Klamath Hydroelectric Project contributes to adverse cumulative effects on coho salmon by blocking access to tributary habitats upstream of Iron Gate dam. The project contributes to the cumulative effects associated with nutrient inputs from upstream, non-project sources by providing seasonal increases in nutrients and contributing to diurnal fluctuations in dissolved oxygen levels and pH downstream of Iron Gate dam associated with plankton blooms in the project reservoirs. Several project effects act in a cumulative manner to contribute to disease losses downstream of Iron Gate dam, including an increase in the density of salmon spawning below the dam, increased habitat for disease pathogens and their alternate hosts due to seasonally increased nutrient inputs and armoring of the stream bed, which provides a stable substrate for the growth of attached algae, and increased disease susceptibility caused by stressful water quality conditions. Although little information is available on the effects of these diseases on coho salmon, the high incidence of disease on Chinook salmon increases the potential for infection of coho salmon.

Although implementing the NMFS/Interior fishway prescription would provide access to upstream tributary habitats, we have serious reservations about the survival rates of outmigrating smolts passing through Copco and Iron Gate reservoirs due to potential losses from fish predation and the cumulative stress from passing through multiple screening facilities, especially when stressful water quality conditions exist during the later part of the outmigration season. Because it would not involve passage past multiple dams and reservoirs, we conclude that implementing a trap and haul program to above J.C. Boyle dam would be a more effective method to restore anadromous fish, including coho salmon, to Spencer Creek, which contains the majority of potential coho salmon habitat upstream of Iron Gate dam. The same goal could also be accomplished by removing Iron Gate and Copco No. 1 dams and providing effective fish passage at Copco No.2 and J.C. Boyle dams, which would also serve to reduce adverse effects on water quality downstream of Iron Gate dam.

3.3.5.3.2 Shortnose and Lost River Suckers

Habitat conditions for the two federally listed sucker species have been degraded over the past 150 years by agriculture, grazing, forestry, and to a smaller degree, urbanization (FWS, 2002a). Nearly all streams and rivers in the Klamath basin have been degraded, some seriously, by the loss of riparian vegetation, geomorphic changes, introduction of return flows from agricultural drainage ditches and water pumped from drained wetlands, stream channelization, dams, and flow reductions from agricultural and

hydroelectric diversions. Most water bodies in the basin fail to meet state water quality criteria. Wetland losses have been especially harmful for sucker populations, since wetlands provide habitat for larval and juvenile suckers and have important water quality functions. Along the perimeter of Upper Klamath Lake, about 40,000 acres of wetlands have been diked and drained for agriculture, and extensive amounts of wetland have been drained elsewhere in the basin. Lower Klamath and Tule lakes no longer support suckers or have been reduced to a few hundred acres of suitable habitat.

The Klamath Hydroelectric Project causes mortality to suckers that are entrained through turbines at the mainstem developments downstream from Keno dam. Upstream migration of suckers is blocked by Iron Gate and the Copco dams, which do not have fish ladders, and the ladders at J.C. Boyle and Keno dam do not meet criteria for sucker passage. However, prior to the construction of the Klamath Hydroelectric Project, the Klamath River downstream of Lake Ewauna did not include any lake or reservoir habitat suitable to support rearing of these species. Based on their limited swimming ability compared to salmonid species, it is unlikely that any suckers that moved downstream past the high gradient rapids in the Keno and J.C. Boyle peaking reaches would be able to return upstream to suitable rearing habitat, and they were probably lost from the spawning population. Accordingly, we conclude that it is unlikely that the Klamath Hydroelectric Project has contributed to adverse cumulative effects on the shortnose and Lost River suckers.

3.3.5.4 Unavoidable Adverse Effects

If the project is relicensed without removal of Iron Gate or Copco No. 1 dams, the project would likely continue to adversely affect water quality conditions downstream of Iron Gate dam, which has the potential to adversely affect juvenile coho salmon during their outmigration from tributaries to the lower Klamath River. Although some entrainment mortality of shortnose and Lost River suckers would continue, this would have no effect on sucker populations upstream of Link River dam.

This project would not result in unavoidable adverse effects on terrestrial threatened and endangered species.

3.3.6 Recreational Resources

3.3.6.1 Affected Environment

Recreational resources associated with the project extend along the California-Oregon border from Klamath Falls to Iron Gate reservoir and include both developed recreational facilities and dispersed recreational opportunities. In the following section, we first describe the regional recreational setting and then the recreational resources associated with the project, including a discussion of latent demand for recreational facilities at the project and visitor survey results.

3.3.6.1.1 Regional Recreational Setting

Rivers, streams, and lakes are common throughout the mountainous landscape, and there are also grasslands in the high plateau areas of the region. Major routes of access in the region include Interstate Highway 5 (I-5), and state highways 66, 97, and 140. There are also numerous paved and unpaved public roads that provide access throughout the region. Most recreational opportunities in the region require several hours drive from the project as well as from Yreka, Ashland, and Klamath Falls, which are the three major population centers in the region (see figure 1-1). Although there are also a few small communities scattered throughout, in general, the region can be characterized as rural.

Public Land

Although most of the land within the region is privately owned and managed for agricultural uses and timber production, the Bureau of Land Management, Forest Service, National Park Service (NPS),

and FWS manage public lands within the region for many uses including recreation. The Bureau manages public lands primarily in the portions of the region in Oregon. The public lands managed by the Forest Service are within the Klamath and Fremont-Winema national forests.

The Klamath National Forest (KNF) in north-central California consists of about 1.7 million acres, and the 300 miles of rivers within the forest include 152 miles of river that are designated national Wild and Scenic Rivers. KNF lands and resources offer opportunities for angling, wildlife viewing, hunting, whitewater and flatwater boating, golf, hiking, mountain biking, equestrian use, skiing, off-highway vehicle (OHV) and snowmobile use, mountain climbing, and spelunking. There are 28 developed campgrounds within the KNF, and dispersed day and overnight use occurs in various locations throughout the forest.

The Fremont-Winema National Forest in south-central Oregon on the eastern slopes of the Cascade Mountain range consists of 2.3 million acres. The lowest elevations of the forest adjoin Upper Klamath Lake where there are marshes, lakes, forested slopes, and wide basins. There are 22 developed campgrounds and 9 day-use areas across the forest; most campgrounds and some day-use facilities require visitors to pay a fee. Recreational opportunities are similar to those provided on the KNF and also include downhill ski areas and hangliding sites.

The NPS manages two areas within the region. Lava Beds National Monument, about 25 miles southeast of Klamath Falls, provides visitor education opportunities for this landscape dominated by striking volcanic features through cave tours, interpretive walks, and campfire programs. Developed recreational facilities include trails, and sites are provided for day and overnight use. Crater Lake National Park, about 25 miles north of Klamath Falls, provides similar recreational opportunities and facilities focused on Crater Lake. Entrance and overnight-use fees are required for both areas.

Located in an area with abundant wetlands, there are also state and federal lands specifically managed for wildlife habitat in the region. FWS manages five wildlife refuges in the region that provide wildlife viewing and hunting opportunities. Visitors can enjoy watching wildlife on canoe, pedestrian, and auto trails and participate in environmental education programs at these refuges. There are also two state-managed wildlife areas in the region that provide hunting and wildlife viewing opportunities.

Wild and Scenic Rivers

Portions of the Klamath River between its headwaters in Oregon and the Pacific Ocean are designated as national Wild and Scenic River. As part of the designation process, segments of the river are nominated and classified based on outstandingly remarkable values (ORV) which reflect the characteristics contributing to its importance. The 11-mile segment of the Klamath River from the J.C. Boyle powerhouse to the California-Oregon border was designated as Wild and Scenic by the Secretary of the Interior in response to a petition by the governor of Oregon, with ORVs for quality whitewater boating, diverse wildlife, prehistoric sites, quality rainbow trout fishery, habitat for endangered species, historic places, scenery, and evidence of Native American traditional uses. In particular, the almost continuous series of 46 rapids with chaotic hydraulics creates a high quality whitewater boating resource, and the rainbow trout fishery creates high quality angling opportunities.

The lower portion of the Klamath River beginning at 3,600 feet downstream of Iron Gate dam to the Pacific Ocean (about 189 miles) was also designated as a national Wild and Scenic River by Congress in 1981. There are 286 miles (including portions of the Salmon and Scott rivers and Wooley Creek) of which 12 miles are classified as “wild,” 24 miles as “scenic,” and 250 miles as “recreational.” The ORV for this river is anadromous fisheries (steelhead and salmon). The importance of anadromous fisheries extends into cultural, recreational, and socioeconomic resources. The Forest Service notes that the river itself is an important recreational corridor through the forests, and the flow and clarity of the water affect the recreational experience. River communities within the forest boundary depend on resources that the river has historically provided, most notably fisheries resources and boatable flows. A decline in fish

production in the past few decades has triggered a decline in the guide and resort industry, the Native American fishery (commercial, subsistence, and ceremonial) and the ocean commercial and sport fishery (Forest Service, 2004). This river segment is located downstream of all project features.

Regional Recreational Opportunities and Demand

The expansive region offers settings for a wide spectrum of recreational activities on reservoirs and lakes. There are 10 reservoirs and lakes similar to the size of the project reservoirs and three much larger than the project reservoirs. All reservoirs and lakes in the region, except for Copco No. 2, have boat ramps and provide opportunities for boating (high- and low-speed), fishing (shoreline and boat), and day-use; there are also some that do not allow motorized boating. Common recreational activities at these waterbodies include swimming and beach activities that have reportedly high and moderate demand in California and Oregon (CDPR, 1998; Oregon Parks & Rec, 2003). As PacifiCorp's review of available information pertaining to existing and future regional recreational demand noted (PacifiCorp, 2004c), the supply of boat launches in the region is currently meeting demand; however, as activity participation and population trends continue to rise, demand may eventually exceed the existing supply.

Angling occurs at the many lakes and reservoirs in the region that have excellent trout fisheries; some reservoirs in the region are stocked with trout. Table 3-85 lists rivers in the region providing opportunities to catch Chinook and coho salmon and steelhead, and trout (see figure 1-1).

Table 3-85. Regional rivers with angling opportunities. (Source: PacifiCorp, 2004c, modified by staff)

River	Fish Species[a] Caught	Common Types of Fishing
Lower Klamath River	Chinook salmon; coho salmon; steelhead; native trout	Drift boat, powerboat
McCloud River	Native trout	Fly fishing, bank fishing
Pit River	Native trout; brown trout; smallmouth bass; rough fish	Fly fishing, bank fishing
Rogue River	Chinook salmon, coho salmon, steelhead	Drift boat, powerboat, fly fishing
Salmon River	Chinook salmon, steelhead, resident trout	Fly fishing, bank fishing
Scott River	Chinook salmon, steelhead, resident trout	Fly fishing, bank fishing
Smith River	Chinook salmon, coho salmon, steelhead	Drift boat, powerboat, fly fishing, bank fishing
Trinity River	Chinook salmon, steelhead, sturgeon, American shad, lamprey	Drift boat, powerboat, fly fishing, bank fishing
Upper Sacramento River	Chinook salmon, native and stocked trout, American shad	Fly fishing, bank fishing

[a] The term 'native trout' refers to rainbow trout populations and 'resident trout' may include populations of brown and brook trout as well as rainbow trout.

The Klamath River supports a genetically unique population of rainbow trout able to survive the naturally high temperatures and acidity of the river. With an abundant trout population, the Klamath River is considered to be one of the finest fisheries in Oregon. There is a high demand for fishing in California and moderate demand in Oregon (CDPR, 1998; Oregon Parks & Rec, 2003). Residents of local communities do a majority of the fishing on rivers within this region. Visitors travel to the region to fish especially from the San Francisco Bay Area and Portland; some visitors pay for fishing guides or charter services to enhance their experience.

The regional study area includes at least 10 rivers that provide a variety of whitewater boating opportunities requiring different skill levels. The Rogue River has the highest existing level of use, whereas the other rivers have more moderate levels of use. Several of the rivers have commercial whitewater outfitters, including the Rogue, Upper Sacramento, and Klamath rivers. The Klamath and Rogue rivers are the only two rivers in the region that provide year-round flows adequate for whitewater boating. In general, factors contributing to higher levels of whitewater use are (1) rivers that are close to urban centers, (2) have year-round flows that are suitable for boating, and (3) where commercial outfitters offer trips. Conversely, rivers with (1) difficult access, (2) require advanced or expert boating skills, and (3) experience low flows tend to have relatively lower levels of use. Table 3-86 lists regional rivers with whitewater boating opportunities.

Table 3-86. Rivers with whitewater boating opportunities in the region. (Source: PacifiCorp, 2004c, modified by staff)

River	State	Comparative Level of Use	Boating Class Type[a]	Miles of Boatable Whitewater	Factors Affecting Use Levels
Clear Creek	CA	Low	IV+	7	Difficult access
Upper Klamath River[b]	CA	Moderate	III-IV+	31	Remote, not suited for beginner or intermediate boaters, unless accompanied by a commercial outfitter
Lower Klamath River[c]	CA	Moderate	II-V	122	Most skill levels
McCloud (tributary of the Sacramento)	CA	Moderate	II-IV	35	Proximity to I-5, most skill levels, low flows in summer
Pit River (tributary of the Sacramento)	CA	Low	IV-V	34	Fragmented/short runs with long stretches of flatwater between, remote location
Rogue River	OR	High	III-V	100+	Easy access, most skill levels, scenery, boatable year round, shoreline suitable for camping, many commercial outfitters
Salmon River (tributary of the Klamath)	CA	Moderate	III-V	44	Requires advanced/expert boating skills
Scott River (tributary of the Klamath)	CA	Low	III-V	20	Recommended for expert boaters only
Smith River	OR, CA	Low	III-V	100+	Very remote, Requires advanced/expert boating skills, low summer flows

River	State	Comparative Level of Use	Boating Class Type[a]	Miles of Boatable Whitewater	Factors Affecting Use Levels
Upper Sacramento River	CA	Low	III-V	36	Proximity to I-5, difficult access, average solitude
Trinity River (tributary of the Klamath)	CA	Moderate	III-V	100+	Most skill levels, easy access,

Note: I-5 – Interstate Highway 5

[a] American Whitewater International Scale of Difficulty (AW, 1998).

[b] Upstream of Iron Gate reservoir.

[c] Downstream of Iron Gate dam.

Because much of the region is relatively remote, visitors often plan to stay for more than 1 day during their recreational excursions; both tent and recreational vehicle (RV) camping are popular. Within the region many campgrounds provide a wide spectrum of visitor conveniences (e.g., showers, RV hookups) near lakes and reservoirs. In general, the season of use extends from May to September with peak use occurring on holidays and weekends, and the highest occupancy occurring at facilities located near I-5. The California and Oregon Statewide Comprehensive Outdoor Recreation Plans (SCORPs) report high and low existing demand, respectively, for developed camping experiences. As PacifiCorp's review of available information pertaining to existing and future regional recreational demand noted (PacifiCorp, 2004c), the supply of developed campgrounds in the region is currently meeting demand, although as activity participation and population continue to increase, demand may eventually exceed the existing supply. Although recreational data for both California and Oregon indicate that visitors currently prefer primitive camping settings, interviews conducted during the development of SCORPs indicate that RV camping opportunities may have a greater demand with the aging of the population. For visitors who prefer to camp in a dispersed manner there is abundant opportunity at lakes and reservoirs within the region. Whereas the existing demand for primitive camping in California is high, it is low in Oregon (CDPR, 1998; Oregon Parks & Rec, 2003). The demand for dispersed camping opportunities would likely increase in the future.

Other developed recreational facilities including trails, interpretive displays/centers, and day-use facilities also enhance visitors' experiences within the region. These regional facilities are available mostly on public lands. The existing demand for trail hiking and picnicking is high in California and moderate in Oregon. Of particular note, the existing demand for nature study/wildlife viewing is high in both California and Oregon. The supply of hiking trails, interpretive displays/centers, and day-use facilities in the region is currently meeting demand. As PacifiCorp's review of available information pertaining to existing and future regional recreational demand noted (PacifiCorp, 2004c), however, as activity participation and population continue to trend upwards, demand may eventually exceed the existing supply.

Activities with increasing participation levels in California and Oregon over the last 20 years include bicycling (paved surfaces), nature study/wildlife viewing, and OHV use. The levels of participation in mountain biking (unpaved surfaces), dispersed camping, kayaking/canoeing/rafting, and fishing (freshwater) have not changed much there over the last 20 years. Participation levels have not decreased for any of the recreational activities in the region. Interviews conducted during the development of the SCORPs indicated that there would likely be increased numbers of people participating in powerboating/personal watercraft use, sightseeing, wildlife viewing, RV camping resting/relaxing, hiking, and waterskiing. Based on the existing supply of facilities and current use levels

in the region and the projected recreational demand in California and Oregon, additional boat launches, campgrounds (RV and tent), hiking trails, day-use facilities, and interpretation facilities would be needed according to the SCORPs.

3.3.6.1.2 Project Recreational Resources

We identify and describe project-related recreational developments in the following section. Nearby non-project recreational developments are also included to provide a complete description of the available developed recreational facilities; some provide direct public access to the project waters. This section also includes a description of the recreational facilities at the East and West Side and Keno developments even though they are proposed to be removed from the project. Each development includes the reservoir and the downstream river segment located between the dam and upstream of the next development. For example, the recreational resources for the J.C. Boyle development include the J.C. Boyle reservoir and the Klamath River between J.C. Boyle dam and Copco reservoir.

Figures 3-104 through 3-107 show the project recreation facilities. In general, the project provides most types of developed recreational facilities such as boat launches, reservoir access, campgrounds, and day-use areas. Facilities that provide opportunities for persons with disabilities, group use, trail use, swimming, and interpretation and education are notably absent or are in short supply.

East Side and West Side Development

Link River dam defines the upstream boundary of the existing project. There is only one project recreational facility, Link River Nature Trail, at this location. Most, but not all of this trail is included in the existing project boundary. The 1.4-mile trail is designated for pedestrian use only and follows a gated project access road on the west side of the Link River bypassed reach. Since this area is located in the community of Klamath Falls, it is popular among local residents for outdoor activities such as hiking, walking, jogging, and bird watching. The estimated annual use is 25,300 recreation days,[118] and peak occupancy and visitor survey data indicate existing use is below the facility capacity.[119] Although the Link River Nature Trail offers relatively distant views and no close access to the river, spur trails allow visitors to get to the water, particularly at the two ends of the trail. There is a bird-watching blind and four fishing platforms (one that is ADA-accessible[120]) on Upper Klamath Lake. Although the main trail surface is in good condition, there are some maintenance needs at the parking area, including fishing platforms, trail entrance, shoreline access trails, and the bird-watching blind; and the signage is hard to read and out of date.[121]

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[118]A recreation day is defined as one visitor to a recreation area for any reason in a 24-hour period.

[119]PacifiCorp defines capacity levels as follows: below capacity: <40 percent peak season occupancy and <60 percent peak season weekend occupancy; approaching capacity: 40 to 59 percent peak season occupancy and 60 to 79 percent peak weekend season occupancy; at capacity: 60 percent peak season occupancy and 80 percent peak weekend season occupancy; and exceeding capacity: >60 percent peak season occupancy and >80 percent peak weekend season occupancy.

[120]This refers to a facility that meets the criteria under the Americans with Disabilities Act.

[121]Based on site visit by staff in August 2005.

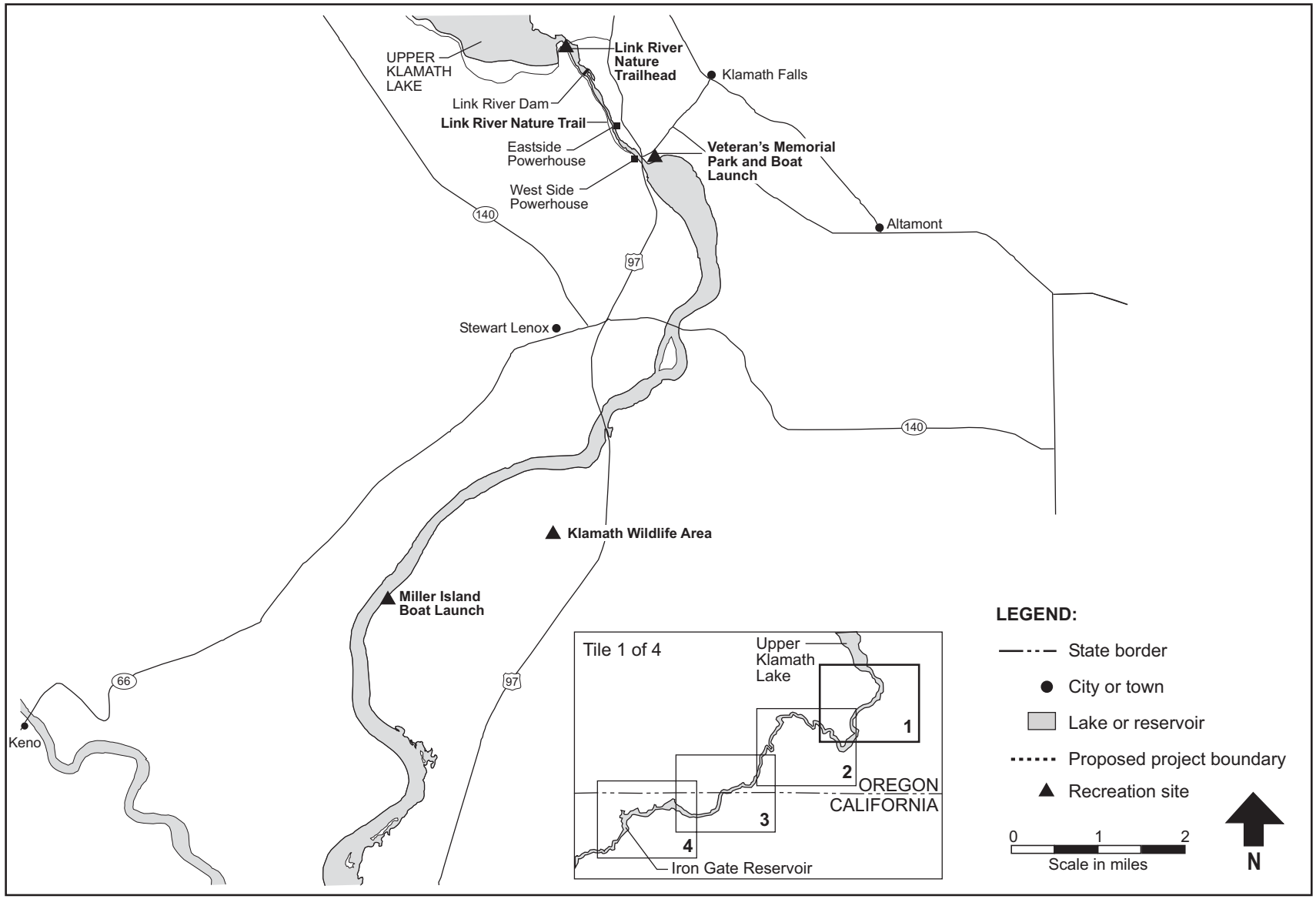

Figure 3-104. Klamath Hydroelectric Project recreation facilities: Link River dam to Keno reservoir. (Source: PacifiCorp, 2004a, as modified by staff)

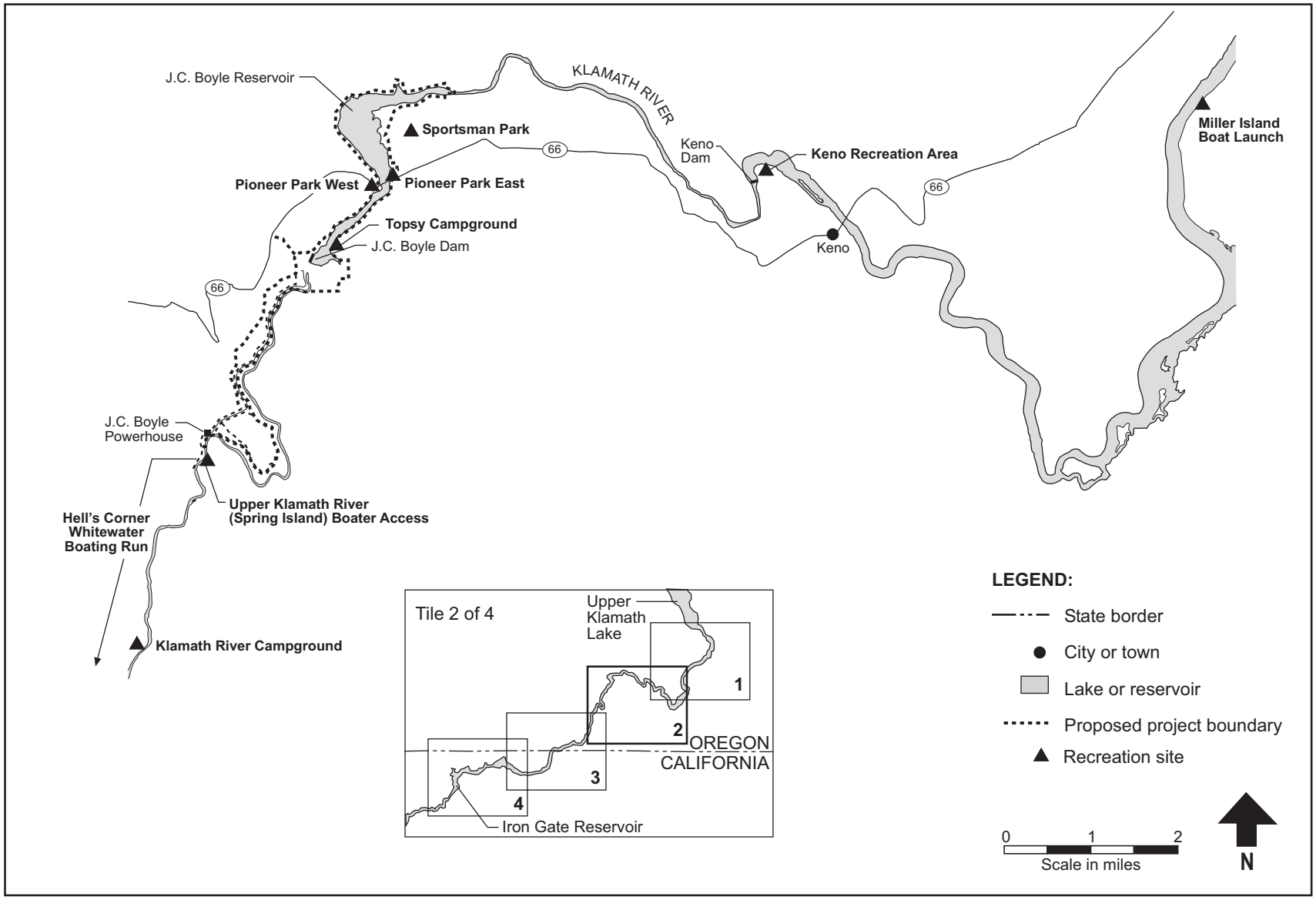

Figure 3-105. Klamath Hydroelectric Project recreation facilities: Keno reservoir to downstream of J.C. Boyle powerhouse. (Source: PacifiCorp, 2004a, as modified by staff)

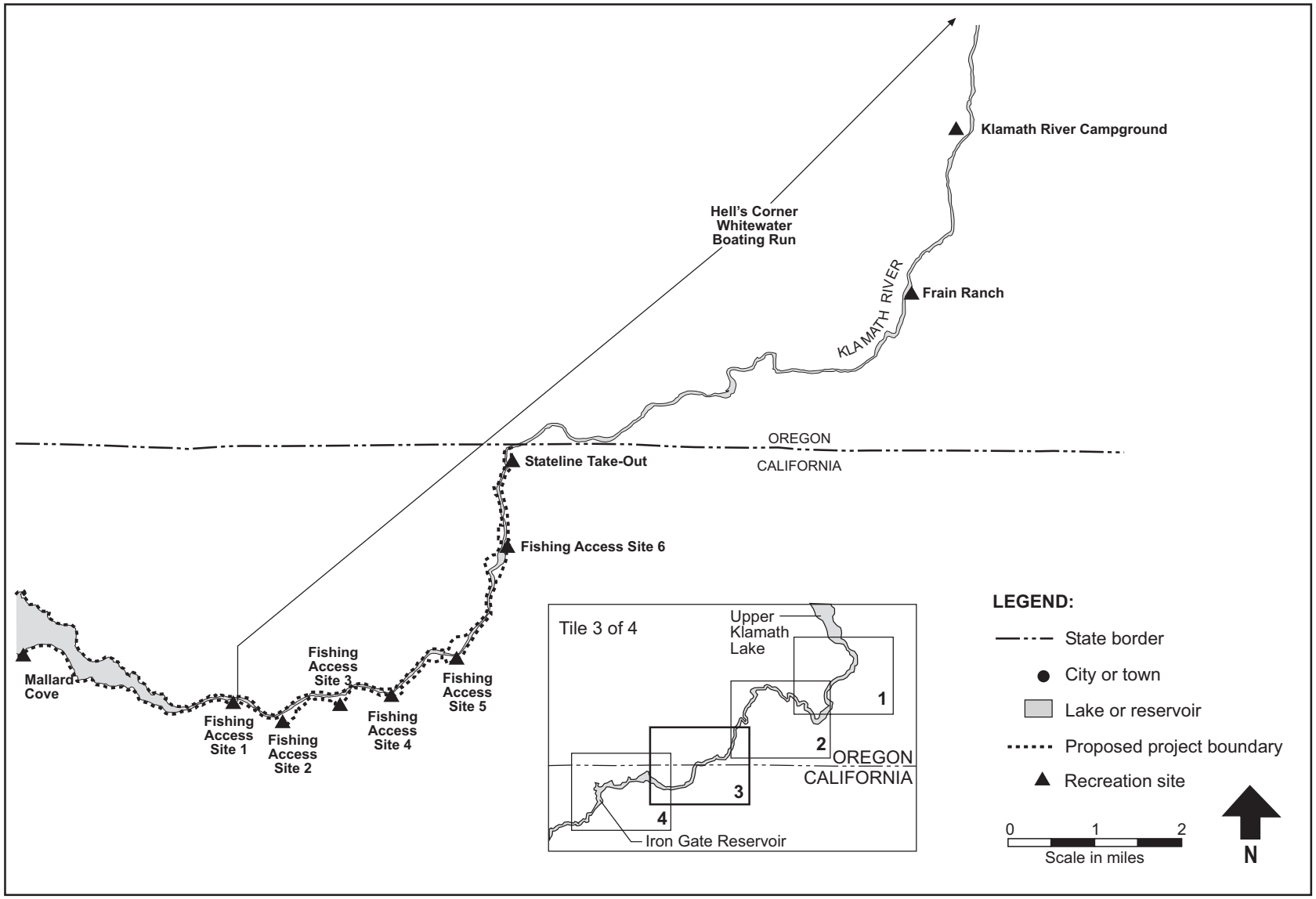

Figure 3-106. Klamath Hydroelectric Project recreation facilities: J.C. Boyle peaking reach to Copco reservoir. (Source: PacifiCorp, 2004a, as modified by staff)

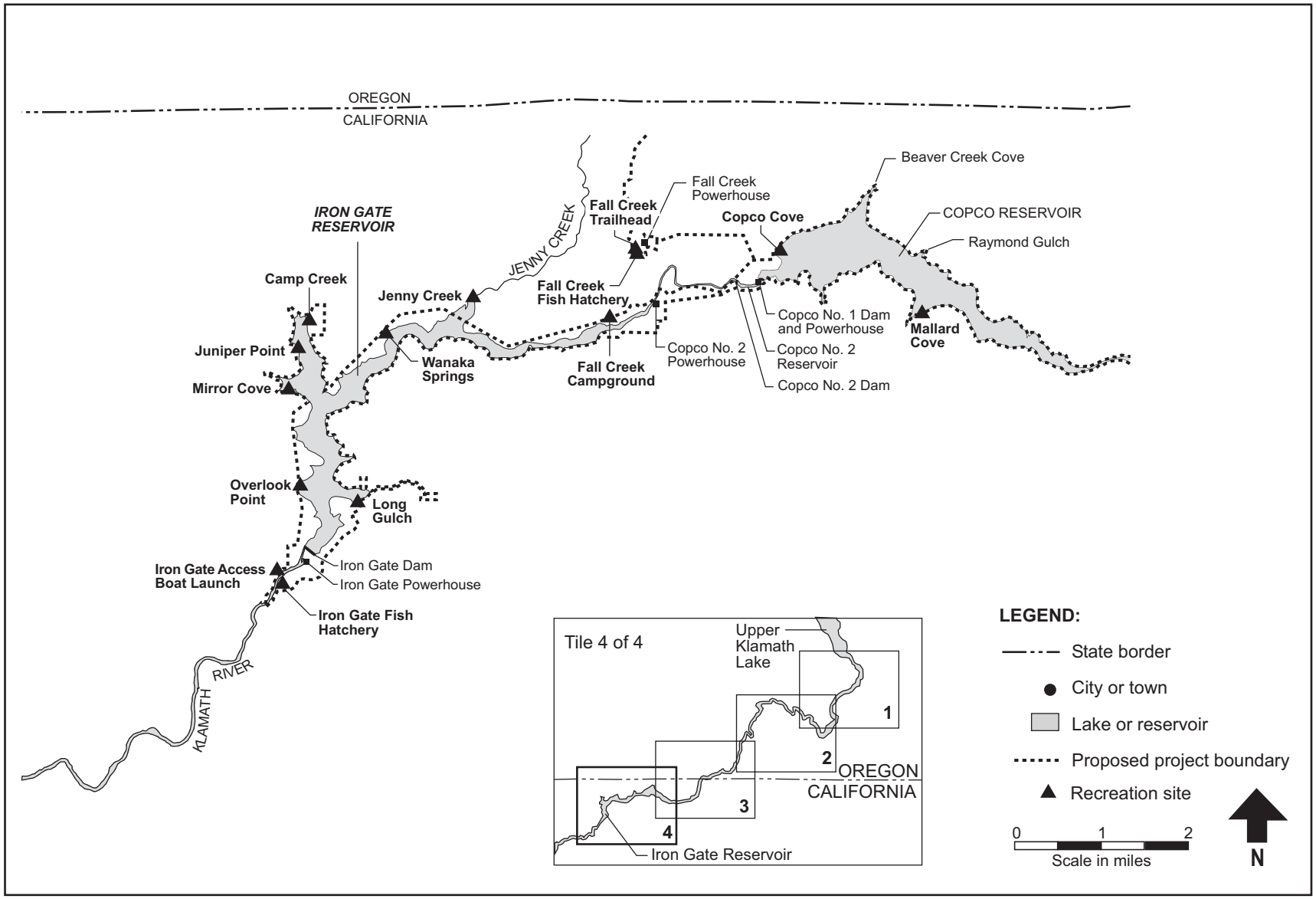

Figure 3-107. Klamath Hydroelectric Project recreation facilities: Copco reservoir to Iron Gate dam. (Source: PacifiCorp, 2004a, as modified by staff)

The Klamath River downstream of Link River dam provides about 1 mile of river suitable for whitewater boating and other river-based activities. Of the total estimated 25,283 recreation days at this location, hiking accounted for 26 percent of the visitor use and bank fishing and picnicking each accounted for 4 percent of visitor use.[122] Whitewater boating use was not detected in PacifiCorp's study observations; however, there are anecdotal accounts of boating use occurring in the reach. There is one short class III/IV rapid and one class II/III ledge drop. At the latter, a play wave forms at high flows which kayakers use. Acceptable playboating begins around 700 cfs and optimal playboating flows are from 2,000 to 3,000 cfs. At base flows, the water level is too low for boating; however, at this flow, there may be opportunities for tubing and bank fishing. Anglers appear to use the river at a few sites where there is access through thick riparian vegetation. Fishing is allowed year round, and the highest use occurs from late winter through spring. The area is mainly used by local residents from Klamath Falls. The river's proximity to this community allows local residents to take advantage of the suitable conditions for these activities.

Table 3-87 summarizes acceptable and optimal flow ranges for whitewater boating and other flow-dependent recreational activities that occur in the Link River bypassed reach. For simplicity, acceptable and optimal flow ranges for the other Klamath River reaches are also included in this table and this information is referenced later in the text presented for each development.

Table 3-87. Acceptable and optimal flow ranges for various river-based activities for reaches of the Klamath River. (Source: PacifiCorp, 2004c, letter from Upper Klamath Outfitters Association to the Commission, filed on November 26, 2006, as modified by staff)

	Acceptable Range (cfs)		Optimal Range (cfs)	
Reach/Opportunity	**Low**	**High**	**Low**	**High**
Link River Bypassed Reach				
Angling	100	1,500	200	1,000
Locational playboating	*1,000*[a]	*3,000*[a]	*2,000*[a]	*3,000*[a]
Keno Reach				
Angling	200	1,500	300	900
Locational playboating	1,100	1,800	1,300	1,600
Standard whitewater boating	*1,000*[a]	*4,000*[a]	*1,200*[a]	*3,000*[a]
J.C. Boyle Bypassed Reach				
Angling	200	1,000	300	400
Technical kayaking	800	1,300	900	1,200
Technical rafting	1,000	1,500	1,200	1,500
Standard whitewater boating	1,300	1,800	1,300	1,700
Big-water rafting	1,600	2,300	1,800	2,300
Big-water kayaking	1,700	3,000	2,000	3,000
Hell's Corner Reach				
Angling	200	1,500	300	500
Technical kayaking	400	1,500	900	1,400
Technical rafting	700	1,400	900	1,400
Low-flow commercial rafting	1,000	1,300	1,000	1,300
Standard whitewater boating	1,400	3,000	1,800	2,800
Standard commercial rafting	1,300	3,500	1,500	3,200

[122]The highest reported use was resting and relaxing (26 percent); however, this categorization does not provide information about the visitors' specific activity. Total estimated visitor use at the project is 191,131 RDs.

Reach/Opportunity	Acceptable Range (cfs)		Optimal Range (cfs)	
	Low	High	Low	High
Big-water boating	1,700	3,700	2,300	3,100
Copco No. 2 Bypassed Reach				
General recreation	10	1,500	50	300
Angling	50	600	50	300
Technical kayaking	200	600	300	600
Standard whitewater boating	600	1,500	800	1,200
Big-water whitewater boating	1,200	Undetermined[b]	1,500	Undetermined[b]
Downstream of Iron Gate Dam[c]				
Angling	800	2,500	1,000	1,500
Technical whitewater boating	600	1,500	800	1,500
Standard whitewater boating	800	4,000	1,500	2,000
Big-water boating	2,500	*30,000*[a]	5,000	*20,000*[a]

Notes: cfs – cubic feet per second

[a] Figures shown in italics based on less precise data.

[b] Unspecified ranges because of high degree of uncertainty.

[c] These data are only for the segment from Iron Gate dam to the Salmon River confluence.

Keno Development

State highways parallel and cross Keno reservoir providing opportunities for bird watching and wildlife viewing. In the fall, waterfowl hunting is a popular activity at Keno reservoir. Existing peak use boating density is only 2 percent of the theoretical maximum density.

According to a 1968 contract between PacifiCorp and Reclamation for the operation of Keno reservoir, the reservoir must be maintained between elevations 4,085.0 and 4,086.5 feet. The contract was developed in compliance with Article 55 of the current license. However, at the request of irrigators with pumps located on the Keno reservoir, PacifiCorp maintains Keno reservoir at 4,085.4 +/- 0.1 foot from October 1 through May 15 and at 4,085.5 +/-0.1 foot from May 16 through September 30 such that reservoir levels are suited for their irrigation pumps. There are no terms or conditions in the current license that require PacifiCorp to accommodate the irrigator's requests.

Most of the land adjacent to the reservoir is privately owned with three points of public access, Miller Island boat launch and the Klamath Wildlife Viewing Area, which are both managed by Oregon Fish & Wildlife and outside the existing project boundary, except for land along the shoreline, and the Keno Recreation Area, which was developed as part of the existing project, is managed by PacifiCorp, and is entirely within the existing project boundary. The access road through the Keno Recreation Area provides public access to the boat launch, Keno dam, and the Klamath River downstream of Keno dam.

Activities at the Keno Recreation Area include camping, fishing, horseshoes, sunbathing, resting/relaxing, and boating. The site has a campground, day-use area, and boat launch. PacifiCorp reports that the interior gravel road and parking areas at the day-use areas and boat launch, as well as the shoreline fishing access areas, are in need of maintenance. The historical display, RV dump station, drinking fountains (particularly the fountain at the historical display that is currently broken), and boat ramp are in need of repair. Over time, recurrent foot traffic between site components has established many user-created trails throughout the footprint of the Keno Recreation Area. The estimated annual use is 6,050 recreation days, and peak occupancy and visitor survey data indicate the existing use is below the facility capacity. Table 3-88 provides a summary of the project and non-project recreational facilities at Keno development.

Table 3-88. Recreational facilities at Keno development. (Source: PacifiCorp, 2004c, as modified by staff)

Facility	Capacity[a]	Facility Components/Comments
Keno Recreation Area-Campground	26 sites	Fee, tables, fire rings, 3 restrooms (1 ADA-accessible), RV dump station, potable water, showers
Keno Recreation Area Day-use Areas	19 picnic tables, 50 parking spaces (in 2 separate areas)	No fee, 2 fire grills, boat launch (12 parking spaces) with boarding dock, playground, historical display[b]
Miller Island Boat Launch		Boat launch (25 parking spaces), restrooms, narrow one-lane access road
Klamath Wildlife Viewing Area		Trail for wildlife viewing, interpretive/education display

Notes: ADA – Americans with Disabilities Act
RV – recreational vehicle

[a] Overnight capacity is presented in terms of the number of sites. Day-use capacity is presented in terms of the number of picnic tables.

[b] There is a historical marker displaying a rack and pinion mechanism used at the old dam site.

The Klamath River downstream of Keno dam provides approximately 5 miles of river suitable for whitewater boating. The reach is rated class III[123] difficulty, and suitable flows are approximately 1,000 to 4,000 cfs with optimum flows between 1,200 and 3,000 cfs. There is not much reported boating use on this reach, which may relate to access, short run length, and sharp volcanic riverbed rock that is hard on boaters and their equipment.

This reach is identified as a popular angling reach of the Klamath River between Link River and Iron Gate dams. Catch records indicate that although angler success is consistently low, there is a greater percentage of larger fish caught in this reach than between J.C. Boyle dam and Stateline access. See table 3-87 earlier in this section for a summary of acceptable and optimal flow ranges for whitewater boating and other flow-dependent recreational activities that occur in the Klamath River below Keno dam.

PacifiCorp did not identify any areas in this development receiving recurrent dispersed recreational use that could potentially cause resource concerns.

J.C. Boyle Development

J.C. Boyle reservoir has 420 surface acres and lies almost entirely on land owned by PacifiCorp. The upstream extent of the project boundary is located at the upstream end of this impoundment. This development is easily accessed by Highway 66, which crosses the reservoir near its midpoint. The topography is gentle-sloping in a forested setting. Visitors to this reservoir enjoy swimming, fishing, boating, day and overnight use, target shooting, and OHV use. Existing peak use boating density is only 37 percent of the theoretical maximum density. The normal maximum and minimum elevations of the J.C. Boyle reservoir are 3,793 and 3,788 feet, a range of 5 feet. Under typical peaking operations, the reservoir fluctuates about 3.5 feet, while average daily fluctuations are approximately 1 to 2 feet.

There are two existing points of public access to the reservoir. Pioneer Park (east and west sides), is a project recreational facility located on PacifiCorp land, managed by PacifiCorp, and within the

[123]Class III, intermediate, class IV, advanced, and class V, expert, rapids as rated by American Whitewater using the International Scale of River Difficulty (AW, 1998).

existing project boundary. Pioneer Park is a day-use facility with two separate areas located on opposite ends of the Highway 66 Bridge that crosses the reservoir. Visitors enjoy picnicking, swimming, and boating at this facility, which has day-use sites, dirt-surfaced and concrete tie boat launches, and interpretive signs. Oregon Department of Transportation replaced this bridge during 2006, and our observations during November 2006 indicate that public access to the reservoir continues to be provided on the east and west sides of this bridge. The estimated annual use is 16,700 recreation days, and peak occupancy and visitor survey data indicate the existing use is below the facility capacity. PacifiCorp states that the dirt- and gravel-surfaced roads and parking areas and boat launch are rough and in need of maintenance. PacifiCorp reports that there are plans to realign Highway 66 where it crosses the reservoir. The existing bridge is not high enough above the water to allow boats to cross underneath; the new bridge would likely be constructed to allow boats to pass to use both ends of the reservoir. Road realignment may eliminate the east side portion of Pioneer Park. The second facility, Topsy Campground, is located on Bureau of Land Management-managed lands and was constructed and is operated and maintained by the Bureau, even though it is within the existing project boundary. Although Topsy Campground provides public access to the reservoir, PacifiCorp does not consider this facility to be a project recreational facility.

Within 0.25 mile of the reservoir, the Sportsman's Park, managed by Klamath County under a lease from PacifiCorp, provides camping sites and designated areas for activities such as OHV use and target shooting. Although this facility is located on land owned by PacifiCorp, it is not within the existing project boundary, and there is currently no access to the reservoir from this facility. Peak occupancy and visitor survey data indicate the existing use at these recreational facilities near the reservoir is approaching facility capacities. Table 3-89 summarizes the recreational facilities at J.C. Boyle reservoir.

Table 3-89. Recreational facilities at J.C. Boyle reservoir. (Source: PacifiCorp, 2004c, as modified by staff)

Facility	Capacity[a]	Facility Components/Comments
Pioneer Park Day-use Area	17 picnic tables (in two separate areas)	Fire grills, 2 restrooms (1 ADA-accessible), boat launch at each development[b], interpretive signs[c]
Topsy Campground	16 sites	Bureau of Land Management-managed facility, fee, boat launch with boarding dock, 2 day-use sites, 4 restrooms (none ADA-accessible), RV dump station, accessible fishing pier
Sportsman's Park	16 picnic tables	Operated under lease from PacifiCorp, shooting range, OHV area, archery range, model aircraft flying field, day (primarily) and overnight (limited) use, group use, 4 restrooms (none ADA-accessible)

Notes: ADA – Americans with Disabilities Act
Bureau of Land Management – U.S. Department of the Interior, Bureau of Land Management
RV – recreational vehicle
OHV – off-highway vehicle

[a] Overnight capacity is presented in terms of the number of sites. Day-use capacity is presented in terms of the number of picnic tables.

[b] Pioneer Park (East) has a boat ramp with two lanes (concrete ties) and an area for hand launching small watercraft. Pioneer Park (West) has a dirt surfaced boat launch.

[c] Interpretive signs for the Applegate Trail.

The gentle sloping land on the north and west side of J.C. Boyle reservoir enables vehicular access to the shoreline. Although the area is posted to prohibit overnight use, such use exists. PacifiCorp

identified 17 dispersed use sites along the reservoir shoreline and immediately below the dam along the river. These sites have documented resource effects related to recreational use including erosion, trash accumulation, sanitation problems, and vegetation removal.

Vehicular access into the Klamath River Canyon, which includes both the bypassed and peaking reaches, is possible from both sides of the river. The north side has better roads and is where most recreation users enter the canyon. The fishing, camping, and day-use opportunities and boating access below the J.C. Boyle powerhouse on the north side of the river are all reached by a dirt- and gravel-surfaced access road that connects to Highway 66; as the road proceeds downstream from the J.C. Boyle powerhouse, it is best suited for high clearance vehicles. Access on the south side of the river is by a more difficult route—the Topsy Grade. Most of this road is located upslope from the river, and access to the river does not generally exist except near Frain Ranch and downstream from Stateline where there are access roads to the river that connect to the Topsy Grade and the Ager-Beswick Road. Without exception, roads on the south side of the river are rough and best suited for high-clearance or four-wheel drive vehicles.

The Klamath River downstream of J.C. Boyle dam and upstream of the J.C. Boyle powerhouse (J.C. Boyle bypassed reach) provides about 5 miles of river suitable for whitewater boating and other river-based activities. Although this reach offers class III-IV+ rapids, suitable boating conditions occur infrequently and only when the upstream storage (Upper Klamath Lake, Keno, and J.C. Boyle reservoirs) capacity is full and the J.C. Boyle powerhouse capacity is exceeded. The J.C. Boyle canal parallels this reach, and there are instances where material sidecast from the canal has fallen into the river channel. Based on our observations during the site visit, the sidecast material that has reached the bypassed reach channel could form an obstacle for whitewater boaters. In fact, PacifiCorp reports that during its controlled flow boating study at this reach, most rafters portage around the "sidecast slide" at flows of 960 cfs or less, and most kayakers portage around this obstacle at flows of 690 cfs or less. There is road access to the reach near the dam and powerhouse, and an upslope road parallels the river between these points. Although the road is generally between one- and two-tenths of a mile from the river channel, the slope between the road and the river is extremely steep. Signage at the powerhouse discourages parking and shoreline use in the vicinity of the powerhouse.

There are also opportunities for trout fishing and general riverside recreation at the few benches and clearings in the riparian zone along the bypassed reach. This reach and the Keno reach are two popular angling reaches of the Klamath River between Link River and Iron Gate dams. Catch records indicate good angler success, although fish size has typically been smaller than fish caught in the Keno reach and rarely exceeds 16 inches. See table 3-87 for a summary of acceptable and optimal flow ranges for whitewater boating and other flow-dependent activities in the J.C. Boyle bypassed reach.

The recreational opportunities in the J.C. Boyle peaking reach focus on the Klamath River which is a nationally designated Wild and Scenic River. The Bureau of Land Management manages the recreational activities in the river corridor north of the Stateline access, primarily whitewater boating, angling, and camping. Elements of the landscape that contribute to high recreational value of this river segment include (1) almost continuous class IV and IV+ rapids for whitewater boating; (2) an undeveloped setting where human development is not apparent; (3) abundant wildlife that provides wildlife viewing and hunting opportunities; (4) one of the finest fisheries with a unique population of rainbow trout; (5) high quality scenery in the form of tall vertical cliffs, diverse vegetation, and flowing river; and (6) historic and pre-historic cultural resources that add complexity to the recreational value of the river.

In terms of whitewater boating opportunities, the most important reach of the Klamath River is located below the J.C. Boyle powerhouse. The Bureau of Land Management manages whitewater

boating use in this 17-mile reach, known as the Hell's Corner run.[124] Commercial boating use is allowed by permit only,[125] and there is a set commercial capacity of 10 outfitters or 200 clients per day on the reach; private boating use does not have a set limit. The Bureau of Land Management established 250 persons per day as the overall whitewater boating carrying capacity for the reach. Factors constraining the carrying capacity are vehicle congestion at the take-out locations near Copco reservoir and the limited size and number of areas that can be used to scout rapids (FERC, 1990). Commercial boating use accounts for approximately 90 percent of the existing use; most are single-day trips and there are some overnight trips. Table 3-90 lists the estimated annual boating use for this reach for 1994 to 2001. These data show that whitewater boating use peaked in the mid-1990s at around 6,000 recreation days per year, and recently has fluctuated between about 4,000 and 5,000 recreation days per year.

Table 3-90. Estimated annual whitewater boating use between J.C. Boyle powerhouse and Copco reservoir (1994—2001). (Source: PacifiCorp, 2004c)

Year	Recreation Days
1994	5,206
1995	6,365
1996	6,207
1997	5,826
1998	4,395
1999	4,897
2000	5,369
2001	3,699
Average	5,250

Whitewater boating use includes both rafting and kayaking. Rafting use, in particular, depends upon operation of the J.C. Boyle powerhouse and generally occurs only when at least one generator is operating. When one generator is operating at optimum efficiency (typical summer conditions), the flow in the peaking reach is usually about 1,500 cfs, including about 350 cfs accretion flow from the bypassed reach. When two generators are running (typical winter and spring, sometimes summer and fall conditions), the flow increases to about 2,700 cfs, including accretion flow. These flow levels are not continuous and flows of this magnitude create hydraulic conditions suitable only for the most experienced boaters. Although more challenging than one turbine and relatively infrequent during the summer, some clients of commercial outfitters travel great distances to take advantage of two turbine flows, according to the Upper Klamath Outfitters Associations' comments on the draft EIS filed on November 24, 2006. Whitewater boating typically occurs from April through October, and about 80 percent of the whitewater rafting use occurs during July, August, and September.

PacifiCorp investigated suitable and optimal whitewater boating opportunities on this reach (PacifiCorp, 2004c). Based on the magnitude of flows, there are two types of boating opportunities available which PacifiCorp labels, 'standard' and 'big water,' reflecting the degree of difficulty and challenge provided by the hydraulic forces. The reach is boatable at about 320 cfs (base flows) using hard shell and inflatable kayaks. Standard whitewater boating opportunities begin at about 1,000 cfs, reach acceptable levels at about 1,300 to 1,400 cfs, and become optimal for commercial trips at about 1,500 cfs, offering mostly class IV rapids. The optimal range of flows for standard boating is from 1,000 to 2,000 cfs. Big water whitewater boating opportunities exist at flows exceeding 2,000 cfs, offering class IV and IV+ rapids. The optimal range of flows for big water boating is from 2,400 to 3,000 cfs.

[124] The run is named after a specific section of the peaking reach known as Hell's Corner.

[125] The Bureau of Land Management has issued permits to more than 20 outfitters to operate whitewater boating trips on this reach.

Scoping comments and information provided by a commercial outfitter (letter from N. Hague, Noah's River Adventures, to M.R. Salas, Secretary, FERC, dated April 26, 2004) indicate flows at or above 1,500 cfs are preferred and that the reach is not suitable for boating below this level because of safety considerations. At flows less than 1,400 cfs, rocks are not sufficiently covered which increases the potential for boats to hit or bump them causing accidental swims, and this increases the potential for injuries. Commercial outfitters also state that flows over 3,000 cfs are not suitable for commercial boating because of safety concerns. In addition, PacifiCorp reports in the Recreation Resources Final Technical Report that the Bureau of Land Management considers 1,500 cfs the minimum raftable flow for this reach. Subsequent correspondence from the Bureau of Land Management (letter from S. Thompson, Manager, FWS [Interior], to M.R. Salas, Secretary, FERC, dated December 1, 2006) indicates that the agency considers 1,500 cfs an optimum and not a minimum raftable flow. The ALJ decision also states that 1,500 is the optimum flow for commercial whitewater boating trips.

The timing and duration of the releases are also critical for commercial operators so they can offer their clients reasonable trip itineraries. Four hours of release beginning at 10 a.m. provides commercial operators with sufficient flow and time to complete quality trips for their clients. Shorter launch windows of 1 to 2 hours, such as those occurring in drought years in the 1990s are possible; however, the time constraint would require giving boaters advanced notice to avoid being stranded. A shorter launch window would likely increase the boat density which would probably lessen the quality of experience for visitors.

In addition to whitewater boating, other forms of flow-dependent recreational activities occur in the J.C. Boyle peaking reach. Based on field observations PacifiCorp reports that angling use between J.C. Boyle powerhouse and the California-Oregon stateline appears low and may be related to difficult access to the river. See table 3-87 earlier in this section for a summary of acceptable and optimal flow ranges for whitewater boating and other flow-dependent recreational activities that occur in the J.C. Boyle peaking reach.

Between J.C. Boyle dam and the Stateline Take-out, there are recreational facilities constructed and managed by the Bureau of Land Management on public land at the Spring Island boater access and Klamath River Campground. The Spring Island boater access is the put-in location for commercial and private whitewater boaters. This facility has a launch area, restrooms, changing room, tables, and informational signage. The estimated annual use is 5,250 recreation days, and peak occupancy and visitor survey data indicate the existing use is below the facility capacity. This facility is not included within the existing project boundary.

The Klamath River Campground has three campsites with few amenities; there is a vault restroom, and the facility has maintenance needs. The estimated annual use is 1,000 recreation days, and peak occupancy and visitor survey data indicate the existing use is below but approaching the facility capacity. This facility is not included within the existing project boundary. Visitors to this facility are camping here to access the river.

As the Klamath River continues flowing south into California, the landform transitions from a steep-walled river canyon with challenging access to a broad river valley with a developed floodplain and a landscape more forgiving to access. Whereas the river canyon sections of the river in Oregon are mainly public lands managed by the Bureau of Land Management, PacifiCorp owns nearly all of the land within the river corridor between the California-Oregon border and Copco reservoir (some land between Copco Road bridge and fishing access number 1 is privately owned). PacifiCorp leases most of its land for cattle grazing.

Angling use is high in the California portion of the peaking reach of the river, and this is also the take-out location for most whitewater boaters. Consequently, PacifiCorp has created seven points of public access to the river to manage recreational use in a manner compatible with the lease interests. There are six developed public access points (Fishing Access Sites 1-6) developed and managed by

PacifiCorp along the 4.5-mile-long section of the Klamath River; only one site is within the existing project boundary (Fishing Access 1). The seventh site, Stateline Take-out, is managed by both PacifiCorp and the Bureau of Land Management, but is also not within the existing project boundary. The seven access points have portable restrooms (except for one vault restroom on Bureau-managed lands at Stateline), dirt-surfaced parking areas, signage, and pedestrian access to the river. There are instances of maintenance needs associated with road and parking area surfaces, signage, and gates. With the exception of the vault restroom at the Stateline access, there are no ADA-accessible restrooms. There are also no ADA-accessible routes to the river. Estimated annual use at Stateline and Fishing Access Sites 1 to 6 is 3,000 and 3,630 recreation days, respectively. Peak occupancy and visitor survey data show existing use at Stateline is approaching capacity; use at the fishing access sites is below capacity.

Table 3-91 provides a summary of the recreational facilities along the J.C. Boyle bypassed and peaking reaches. PacifiCorp determined that the Spring Island boater access and Fishing Access Sites 1 to 6 are below their capacity and the Klamath River Campground and the Stateline Take-out are approaching their capacity, based on biophysical (e.g., soil erosion), social (e.g., visitor perceptions of crowding), and site capacity (e.g., occupancy data) factors.

PacifiCorp identified four dispersed use sites in this reach between J.C. Boyle powerhouse and Stateline and documented resource effects at these areas related to recreational use. The area of greatest concern is at Frain Ranch where there are many user-created roads with compacted soil and routes located too close to the river. PacifiCorp owns this land; however, it is not included within the existing project boundary. Commercial and private boaters use this site for both day and overnight boat trips. Campers, anglers, and hunters who access the site by vehicle also use Frain Ranch.

Table 3-91. Recreational facilities on the Klamath River between J.C. Boyle dam and Copco reservoir. (Source: PacifiCorp, 2004c, modified by staff)

Facility	Capacity[a]	Facility Components/Comments
Spring Island Boater Access	1 picnic table	Launch area, shoreline fishing access, ADA-accessible vault restroom and changing room, 12 parking spaces, paved loop road, day-use only
Klamath River Campground	3 campsites	Vault restroom (not ADA-accessible)
Stateline Take-out	River access only	Site located on both Bureau of Land Management-managed and PacifiCorp-owned lands. Lower area[b]: day-use only, boat put-in/take-out, shoreline fishing access, 2 portable restrooms (one ADA-accessible), parking area. Upper area[c]: day-use only (although unmanaged overnight use occurs), vault restrooms (ADA-accessible), parking area
Fishing Access Sites 1 to 6	6 sites	Portable restrooms (not ADA-accessible), parking areas, and signage at each site, pedestrian access routes to river

Notes: Bureau of Land Management – U. S. Department of the Interior, Bureau of Land Management

[a] Overnight capacity is presented in terms of the number of sites. Day-use capacity is presented in terms of the number of picnic tables.

[b] Lower portion is managed by both PacifiCorp and the Bureau of Land Management.

[c] Upper portion is managed by the Bureau of Land Management.

Copco Development

This development includes two reservoirs, Copco reservoir and Copco No. 2 reservoir, and the Klamath River to where it enters Iron Gate reservoir. As the project features descend in elevation, the

vegetation transitions from mixed conifer to oak woodland in the vicinity of this development. Similarly, temperatures at this elevation of the project are warmer during the summer months as compared to the upstream developments. Access to Copco reservoir and Copco No. 2 reservoir is from the west by way of either of two paved two-lane county roads (Copco Road and Ager-Beswick Road) that connect to I-5; travel time from I-5 is approximately 1 hour. Copco reservoir is almost entirely located on privately owned land, and Copco No. 2 is located entirely on land owned by PacifiCorp. Because of steep topography, small size (40 acres), narrow configuration, and difficult access, Copco No. 2 reservoir has little suitability for recreational use. Project access roads have locked gates, and there is no public access to Copco No. 2. In contrast, Copco reservoir has high recreational suitability, and there is a small residential community at this reservoir. Public roads run along almost the entire length of the shoreline.

Visitors to Copco reservoir enjoy fishing, boating, and day and overnight use. The Copco Lake Community Advisory Committee provides anecdotal reports that there are large quantities of bass, catfish, and trout in Copco reservoir which support recreational angling opportunities, including fishing tournaments, on a regular basis (letter from B. Davis, Chairman, Copco Lake Community Advisory Community Advisory Committee, Montague, CA, to M. Salas, FERC, Washington, DC, dated July 18, 2004). Existing peak use boating density is only 12 percent of the theoretical maximum density. Copco reservoir can fluctuate up to 5.0 feet, from 2,602.5 to 2,607.5 feet, but the average daily fluctuation is approximately 0.5 foot.

There are two points of public access to this reservoir at day-use areas with picnic sites, restrooms, and boat launches; unmanaged overnight use also occurs at these day-use sites. Mallard Cove is a day-use area located on the south shoreline near the mid-point of the reservoir on a parcel of Bureau of Land Management-managed public land and PacifiCorp-owned land. The facility encompasses the entire area between Ager-Beswick Road and the reservoir shoreline; residential development surrounds this site. Only the land along the reservoir shoreline is within the existing project boundary. The estimated annual use is 7,600 recreation days, and peak occupancy and visitor survey data indicate the existing use is below the facility capacity.

Copco Cove is a small day-use area located on the north shoreline approximately 0.5 mile north of the dam on PacifiCorp land and within the existing project boundary. The estimated annual use is 1,250 recreation days, and peak occupancy and visitor survey data indicate the existing use is below the facility capacity. Table 3-92 provides a summary of the recreational facilities at the Copco development. The access roads, parking areas, tables, and grills at both of these day-use areas are in need of maintenance. PacifiCorp determined that these facilities are below capacity based on biophysical (e.g., soil erosion), social (e.g., visitor perception of crowding), and site capacity (e.g., occupancy data) factors.

Table 3-92. Recreational facilities at Copco development. (Source: PacifiCorp, 2004c, as modified by staff)

Facility[a]	Capacity	Facility Components/Comments
Mallard Cove Day-use Area	10 picnic tables/12 fire grills	2 restrooms (none ADA-accessible), boat launch, boarding dock
Copco Cove Day-use Area	2 picnic tables and fire grills	2 restrooms (none ADA-accessible), boat launch, boarding dock

[a] Both located at Copco reservoir.

PacifiCorp identified two dispersed use sites with excessive bare ground potentially related to both recreational use and cattle grazing. The sites are on the north shoreline in the vicinity of Beaver Creek Cove and Raymond Gulch.

The Klamath River downstream of Copco No. 2 dam extends 1.5 miles to the backwater of Iron Gate reservoir. The only access to this river reach is by a steep gravel road that leads to Copco No. 1 and No. 2 dams that is closed to public vehicular access. This reach may offer undocumented boating and fishing opportunities. PacifiCorp determined that the reach provides high quality rapids and scenery. However, it is a short reach and boating requires flows in excess of 200 cfs for kayaks and 600 cfs for standard whitewater boating. Consequently, the minimum flows recommended by various agencies, 730 cfs (discussed in section 3.3.3.2.1, *Instream Flows*), would enhance whitewater boating opportunities at this reach. See table 3-87 earlier in this section for a summary of acceptable and optimal flow ranges for whitewater boating and other flow-dependent recreational activities that occur in the Klamath River downstream of Copco No. 2 dam.

Fall Creek Development

Fall Creek development is the only development in the project that does not include a reservoir. Instead, the recreational resources associated with this development focus on the attributes of Fall Creek in the vicinity of the Fall Creek powerhouse. There is a small day-use area adjacent to a Cal Fish & Game fish hatchery where visitors can park along Copco Road to picnic or hike up to Fall Creek Falls on a 0.2 mile trail. The facility was developed and is managed by Cal Fish & Game and is not within the existing project boundary. The site was closed during the relicensing study period but PacifiCorp estimates that the annual use at this site is low and below capacity. This site has no obvious signage or restrooms, and the trail is poorly maintained. The city of Yreka obtains its domestic water supply from a diversion on Fall Creek that is adjacent to the Fall Creek development. The city of Yreka states concerns with maintaining facility security and providing safety for its water supply amid recreational use occurring in the vicinity of these facilities (letter from Rory McNeil, Mayor, city of Yreka, to the Commission dated November 26, 2006). Table 3-93 provides a summary of the recreational facilities at Fall Creek development. PacifiCorp determined that these facilities are below capacity based on biophysical (e.g., soil erosion), social (e.g., visitor perceptions of crowding), and site capacity (e.g., occupancy data) factors.

Table 3-93. Recreational facilities at Fall Creek development. (Source: PacifiCorp, 2004c, as modified by staff)

Facility	Capacity	Facility Components/Comments
Fall Creek Day-use Area	2 picnic tables	No restrooms, parking area on Copco Road
Fall Creek Trail	0.1-mile trail	Non-motorized trail, terminates with views of Fall Creek Falls

Iron Gate Development

Recreational resources for this development include the area around Iron Gate reservoir and downstream of the dam on the Klamath River to the Iron Gate Hatchery. Most of the developed recreational capacity of the entire project is located at Iron Gate reservoir. There are campgrounds, day-use areas, boat launches, and a scenic overlook. Access to the reservoir is from the west on Copco Road, a paved, two-lane county road that connects to I-5. Visitors to this reservoir enjoy swimming, fishing, boating, and day and overnight use. Among all of the project reservoirs, Iron Gate reservoir is the most popular for waterskiing and powerboating. Existing peak use boating density is the highest of all of the project reservoirs at 47 percent of the theoretical maximum density. The Iron Gate reservoir is maintained between 2,328.0 and 2,324.0 feet, a range of 4 feet. The reservoir is operated on a daily basis over a limited range of approximately 1.5 feet.

The seven developed recreational facilities at the reservoir are interspersed along the north and west shorelines and are all located, at least partially, within the existing project boundary (portions of the Camp Creek, Juniper Point, and Mirror Cove recreational areas are not within the existing project boundary). All of the seven recreational developments provide access to Iron Gate reservoir. PacifiCorp constructed and operates and maintains these facilities. In general, there are maintenance needs and accessibility deficiencies at all of these facilities related to roads, parking areas, signage, restrooms, boat launches, and fishing/boarding docks (PacifiCorp, 2004c).

The Iron Gate Fish Hatchery is also located downstream of Iron Gate dam which Cal Fish & Game operates and PacifiCorp partially funds. At this location, there is a day-use area adjacent to the hatchery with tables, an interpretive kiosk, restrooms, parking area, and an ADA-accessible trail to the river/fish return area. There is public access to the river with a graveled road to the shoreline for launching small boats located on the northwest side of the river (accessed from Copco Road). Both facilities are located within the existing project boundary. PacifiCorp reports that the boat launch and gravel access road to the launch are in need of repair. Table 3-94 provides a summary of the recreational facilities at Iron Gate development.

Table 3-95 provides an assessment of each developed site relative to its existing capacity. PacifiCorp based this comprehensive assessment on biophysical (e.g., soil erosion), social (e.g., visitor perceptions of crowding), and site capacity (e.g., occupancy data) factors.

Table 3-94. Recreational facilities at Iron Gate development. (Source: PacifiCorp, 2004c, as modified by staff)

Facility	Capacity[a]	Facility Components/Comments
Fall Creek Day-use Area	3 tables	Unmanaged overnight use occurs, 1 vault restroom (closed) and 1 portable restroom (not ADA-accessible), hand-launch boating access
Jenny Creek Day-use Area and Campground	6 sites	Co-located within same footprint so sites are used for both day and overnight use, restroom (not ADA-accessible)
Wanaka Springs Day-use Area	6 overnight sites/6 tables	Unmanaged overnight use occurs, fishing dock, 2 vault restrooms and 1 portable restroom
Camp Creek Day-use and Campground	13 overnight/ 6 tables	Development is in 3 separate areas, boat launch (1 vehicle-launch/1 hand-launch), boarding and fishing docks, RV dump station, restrooms, potable water, sports field, interpretive display[b]
Juniper Point Day-use and Campground	9 sites	Co-located within same footprint so sites are used for both day and overnight use, restroom (not ADA-accessible), fishing dock, steep access road
Mirror Cove Day-use and Campground	10 sites	Co-located within same footprint so sites are used for both day and overnight use, boat launch, 2 vault restrooms and 1 portable restroom, site often occupied by groups

Facility	Capacity[a]	Facility Components/Comments
Long Gulch Day-use and Campground	2 tables	Co-located within same footprint so sites are used for both day and overnight use, boat launch, 2 vault restrooms (closed) and 1 portable restroom, access road maintained by PacifiCorp and homeowners group
Overlook Point Day-use area	3 tables	2 vault restrooms (closed) and 1 portable restroom
Iron Gate Fish Hatchery Day-use Area	6 tables	Picnic shelter, visitor center/interpretive kiosk, restroom, ADA-accessible trail to river, seasonal interpretive tours of hatchery for schools, river/ boating access on northwest side of river (small watercraft)

Notes: RV – recreational vehicle

[a] Overnight capacity is presented in terms of the number of sites. Day-use capacity is presented in terms of the number of picnic tables.

[b] Wilkes Expedition historical marker.

Table 3-95. Annual estimated use and capacity assessment at recreational facilities at the Iron Gate development. (Source: PacifiCorp, 2004c)

Facility	Estimated Annual Use (Recreation Days)	Overall capacity assessment
Fall Creek	3,500	Approaching capacity
Jenny Creek	3,700	Approaching capacity
Wanaka Springs	4,150	Exceeding capacity
Camp Creek	15,260	Exceeding capacity
Juniper Point	4,720	At capacity
Mirror Cove	11,140	Exceeding capacity
Overlook Point	1,900	Approaching capacity
Long Gulch	5,225	Below to approaching capacity
Iron Gate Fish Hatchery Day-Use Area	2,200	Below capacity

PacifiCorp identified four dispersed-use sites along the Iron Gate shoreline and documented resource effects potentially related to both recreational use and cattle grazing. These sites appear to be primarily used by anglers for shoreline access; however, the dispersed site near Long Gulch appears to receive widespread[126] recurrent overnight use.

[126]PacifiCorp identified at least five fire rings in its recreation relicensing study.

The Klamath River downstream of Iron Gate dam has high quality angling opportunities extending nearly 200 miles to the Pacific Ocean. The main Klamath River from 3,500 feet downstream of Iron Gate dam is open to fishing year round. This reach attracts and supports several fishing outfitter services that focus on salmon, steelhead, and trout fisheries. An internet search located a website that contains a guide services directory; the listing identifies at least five businesses that offer angling guide services on the Klamath River (The Fish Sniffer, 2006). However, as discussed in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*, angling in the Lower Klamath River is dependent on the annual status of the fall-run Chinook salmon run, so the number of businesses that offer angling guide services changes from year to year. The main run of Klamath River Chinook salmon peaks in late fall and is normally over by mid-January each year; the steelhead season normally starts in November.

Extensive whitewater boating opportunities exist on the 123-mile segment of the Klamath River from downstream of Iron Gate dam to the confluence with the Salmon River. Depending on the river segment and level of flow, there are opportunities for play, standard, and big water boating on mostly class II and III waters. For most reaches, standard boating opportunities range from about 750 to 1,500 cfs, and the optimal flow is about 1,500 to 2,000 cfs. Flows of 3,000 to 5,000 cfs provide powerful hydraulics creating big water boating opportunities. Locational play boating (at School House Wave[127]) can be reliably available for long periods during the summer and attracts considerable use. This wave is boatable at flows between 900 and 1,400 cfs; optimal between 1,000 and 1,300 cfs; and it washes out at flows over 1,400 cfs. See table 3-87 earlier in this section for a summary of acceptable and optimal flow ranges for whitewater boating and other flow-dependent recreational activities that occur in the Klamath River downstream of Iron Gate dam to its confluence with the Salmon River.

Latent Demand at the Project

Latent demand is unmet demand whereby visitors do not have sufficient opportunity to participate in a specific activity because there are no facilities or conditions to allow the activity. PacifiCorp identified five activities, listed below, that likely have some existing latent demand at the project and the accompanying reason(s).

- Non-motorized bicycling—few bike paths, routes, or trails
- Interpretation—few interpretive facilities (other than signboards) such as amphitheaters and campgrounds
- Waterskiing—few courses (clubs only)
- ADA-accessible activities—few accessible facilities
- Group use—no formal group-use facilities available

Visitor Survey Results

PacifiCorp's recreation relicensing study included surveying visitors across the footprint of the project. The Final Technical Report, Recreation Resources (PacifiCorp, 2004c) contains a complete discussion and summary of all visitor survey responses. In the following section, we discuss the responses to a subset of the visitor survey questions that are relevant to existing recreational resources and desired changes.

Indicators of demand for facilities, services, and opportunities are reflected in the responses to the visitor surveys conducted by PacifiCorp. Only about 14 percent of the survey respondents indicated there were activities they would like to participate in but currently cannot. Nearly half of the comments

[127]About 8 miles west of Interstate 5 near Gottville.

received related to facility needs rather than need for opportunities or services. The most frequent facility needs identified were restrooms, showers, and boat rentals. The most frequent activity-based responses identified the desire to participate in motorized water sports (e.g., waterskiing and wake boarding), hiking, and swimming. Other respondents identified the need for RV hookups, swimming areas, motorized and non-motorized trails, and skeet shooting. Positive responses (satisfaction with facilities) were distributed among all of the developments; however, Iron Gate had a somewhat higher frequency of affirmative responses.

Visitor survey responses indicate that, in general, the existing recreational facilities are sufficient to meet visitor needs, and visitors perceive that the recreational facilities are adequately maintained. Only 10 percent of the visitors surveyed indicated maintenance concerns such as unclean restrooms; litter accumulation; needed site upgrades; and the need for road, trail, and boat launch maintenance. The highest frequency of dissatisfaction with facility maintenance (29 of the total 59 negative responses) was at Iron Gate reservoir.

Overall, visitors appear satisfied with the water levels in the reservoir and river. The areas with the lowest acceptability were in the J.C. Boyle bypassed and peaking reaches, which reflects the sensitivity of whitewater boating to the amount of flow in the Klamath River. PacifiCorp states that drought conditions existed during the survey period, which may have caused more visitors to be dissatisfied with water levels.

Water quality concerns were identified in the visitor survey by asking visitors if the water quality had ever affected their visit to the Klamath River area. Affirmative responses ranged from 32 percent at Iron Gate and Link River/Lake Ewauna/Keno reservoirs to 61 percent at the J.C. Boyle bypassed and peaking reaches. The source of concern appears to be the brown, foamy water in free-flowing reaches (most likely associated with organic matter loading) and regular and extensive algae blooms that occur throughout the reservoirs and flowing river extending from Upper Klamath Lake to the Klamath River downstream of Iron Gate dam. Visitors report that algae produces unsavory odors, fouls fishing lines, and reduces the areas available for fishing, swimming, and wading; brown foam also accumulates in river eddies. In 2005, some of the highest recorded levels of toxic algae appeared in blooms on the Klamath River. In response, the North Coast Regional Water Board (memorandum from K.B. Kaley, Staff Toxicologist Applied Risk Assessment Unit to M. St. John, North Coast Regional Water Quality Control Board, Santa Rosa, CA, dated September 1, 2005), the Karuk Tribe, and the U.S. Environmental Protection Agency (EPA) joined other local, state, and federal agencies in warning residents and recreational users of the river to use caution when near such algal blooms. Possible health effects of exposure to *Microcystis aeruginosa* and its microcystin toxin range from mild, non-life threatening skin conditions to permanent organ impairment and death, depending upon exposure time and intensity. Additional discussion of algal blooms is provided in section 3.3.2, *Water Resources*.

3.3.6.2 Environmental Effects

We present the analysis of PacifiCorp's proposed measures, stakeholder terms and conditions, and recommendations in the following three sections: (1) Recreation Resource Management; (2) River Recreation; and (3) Development Decommissioning and Dam Removal. PacifiCorp's proposed recreational measures are outlined in the draft Recreation Resources Management Plan[128] (RRMP) filed by letter to the Commission dated September 29, 2004 (PacifiCorp, 2004j).

[128]PacifiCorp filed a draft RRMP in February 2004 and revised it in September 2004. All references to the draft RRMP are to the September 2004 version of the draft plan.

3.3.6.2.1 Recreation Resource Management

Framework for Recreation Resource Management

In its introduction to the draft RRMP, PacifiCorp proposes to file a final RRMP within 1 year of license issuance.

The Bureau of Land Management specifies that PacifiCorp should, within 1 year of license issuance, develop a RRMP in consultation with the Bureau, and provide copies of the final RRMP filed with the Commission and evidence of consultation to the Bureau of Land Management. The Bureau of Land Management would reserve the right to require changes to the RRMP by filing modifications to the RRMP within 30 days of receiving the final RRMP documentation. Upon Commission approval, the licensee would implement the plan, including any changes required by the Bureau of Land Management.

Oregon Fish & Wildlife and Oregon Parks & Rec both recommend that within 4 months of license issuance, PacifiCorp should form a recreation stakeholder group to assist with the completion of the RRMP. The group would be comprised of representatives from state (including Oregon Fish & Wildlife and Oregon Parks & Rec) and federal agencies, counties, tribes, and other interested parties. Within 1 year of license issuance, PacifiCorp would complete the RRMP.

Our Analysis

PacifiCorp's proposed time frame for finalizing the RRMP is consistent with the agencies' and seems reasonable, given the existence of a draft RRMP that addresses many of the recreational issues associated with relicensing this project. However, PacifiCorp initially did not state that the plan would be finalized in consultation with others, as the Bureau of Land Management specifies and Oregon Fish & Wildlife and Parks & Rec recommend. We expect consultation would be needed since the configuration of the to-be-licensed project cannot be determined prior to license issuance, and the final RRMP would need to reflect as-licensed conditions. Considering the draft plan was developed in consultation with a broad group of recreation stakeholders, the Recreation Work Group, it seems reasonable to continue consulting with appropriate stakeholders during the finalization of the RRMP. Although the Commission cannot require that any entity other than PacifiCorp participate in a recreation stakeholder group, consultation with appropriate stakeholders during plan finalization would ensure that relevant input is considered and incorporated into the final plan. By inviting those agencies identified by PacifiCorp in section 3.1 of the draft RRMP to participate in RRMP finalization, agencies that would serve an advisory role during plan implementation could begin to form a working relationship with PacifiCorp. In response to the draft EIS, PacifiCorp states that it would continue to consult and cooperate with the Recreation Work Group during development of the final RRMP. In addition, including the city of Yreka among the consulted stakeholders when finalizing the RRMP would enable the city's concerns regarding recreational development and use near the domestic water supply diversion in Fall Creek to be addressed.

PacifiCorp did not initially specify that Oregon Fish & Wildlife would serve in an advisory role during implementation of the final RRMP, although Cal Fish & Game would serve in such a capacity. Inviting Oregon Fish & Wildlife to participate in both RRMP plan finalization and implementation would enable Oregon's fish and wildlife resources to be considered on an equal footing with California natural resources. We also consider it appropriate to invite relevant tribal representatives to participate in plan finalization. Recreational activities can have adverse affects on cultural resources and sites of importance to the tribes. Such cultural resources have confidential aspects that cannot readily be divulged to the general public and tribal participation in plan finalization would enable consideration of measures to protect these sensitive resources in the final RRMP. In response to the draft EIS, PacifiCorp agreed that Oregon Fish & Wildlife and tribal representatives should be afforded advisory roles in the finalization and implementation of the RRMP.

Recreational Facility Development

PacifiCorp's draft RRMP proposes site-specific recreational development that it would design, permit, and construct at the project. The proposed facilities would be designed and constructed to comply with ADA, applicable health and safety codes and regulations, and provide design continuity and visitor experiences consistent with the recreational setting where the facility would be located. The proposed facilities would also be designed to minimize facility and site deterioration and O&M costs and protect natural and cultural resources.

The following text is organized by project development beginning at the uppermost elevation of the project and proceeding downstream. We analyze PacifiCorp's proposed developments identified in the draft RRMP and we analyze the terms, conditions and recommendations of stakeholders as they pertain to each of the project developments.

East and West Side Developments. The only recreational facility associated with East and West Side developments is the Link River Trail. This trail is primarily on land owned by PacifiCorp and the trail is maintained by PacifiCorp. PacifiCorp proposes to define future ownership, management responsibilities, and transfer rights of the Link River Trail and corridor lands within a future decommissioning plan for East Side and West Side developments.

Interior recommends PacifiCorp improve the Link River Trail by resurfacing the trail, managing vegetation in the trail corridor, and incorporating river access off the trail. In addition, Interior recommends PacifiCorp develop a trail that connects Veteran's Memorial Park with the Link River Trail.

Our Analysis

The Link River Trail is a project recreational facility that provides public access to project lands and waters. It would be appropriate for it to remain part of the project unless East Side and West Side developments are decommissioned. Since PacifiCorp proposes to decommission both developments, including the disposition of the trail as an item to be addressed in a decommissioning plan would ensure the trail would either be operated and maintained in a safe and suitable manner or it would be removed and the land restored. If the Commission should decide that one or both developments should be decommissioned, a decommissioning plan would provide for relatively short-term measures that would ensure an orderly transition as Commission jurisdiction over the developments is relinquished. Long term recreational enhancement measures, such as resurfacing Link River Trail, or constructing a new trail, would only be appropriate for the Commission to consider if one or both developments were not decommissioned. If the Commission should make such a determination, consideration of such enhancement measures could be addressed in the final RRMP.

Keno Development. The only project-related recreational facility at Keno development is the Keno Recreation Area, which is located on land owned by PacifiCorp and lands of the United States managed by Reclamation. PacifiCorp currently operates and maintains this facility. PacifiCorp proposes to define future ownership, management responsibilities, and transfer rights of the Keno Recreation Area within a future Commission jurisdictional proceeding. PacifiCorp states that Keno dam currently serves no project purposes and therefore should be removed from the project.

Our Analysis

The Keno Recreation Area is currently a project recreational facility that provides public access to project lands and waters. Accordingly, it would be appropriate for this facility to remain part of the project unless Keno development was removed from the project. If the Commission should determine that Keno development serves no project purposes, the Keno Recreation Area would no longer be under the Commission's jurisdiction. However, PacifiCorp or another entity would be free to continue to operate and maintain this facility. If the Commission determines that Keno development serves project

purposes, continued operation and maintenance of this recreational site by PacifiCorp would be appropriate, and provisions for doing so could be included in a final RRMP.

J.C. Boyle Development. PacifiCorp proposes improvements at existing project recreational facilities, and constructing new recreational developments listed in table 3-96. PacifiCorp's proposals for owning, operating and maintaining the recreational facilities and managing dispersed recreational use are also shown in the table.

Table 3-96. PacifiCorp's proposed recreational improvements at J.C. Boyle development. (Source: PacifiCorp, 2004j, as modified by staff)

Facility (Existing or *New*)	**Recreational Improvements**	**Ownership, Operation and Maintenance**
Pioneer Crossing Recreation Area[a]	Install: (1) improved and expanded day-use facilities including sunbathing and picnic areas; (2) new boat launch and parking area; and (3) accessible double vault restroom. Renovate existing parking area (regravel and provide traffic control barriers).	Explore potential management agreement with the Bureau of Land Management to operate this facility, if both parties agree, PacifiCorp to provide annual O&M.
J.C. Boyle Reservoir Loop Trail	*Provide two trailheads and a non-motorized loop trail connecting Pioneer Park, Topsy Campground, and Boyle Bluffs (a 5 mile loop).*	Provide annual trail O&M. Contingent on assessing cultural resources and acquiring easements from other landowners.
Upper J.C. Boyle Reservoir Boating Access	*Provide gravel road access, parking for 10-12 vehicles, and a single accessible vault restroom; modify the shoreline to accommodate small watercraft access.*	Access to this site is on an existing road through Sportsman's Park. Provide annual O&M.
Boyle Bluffs Day-Use Area and Campground	*Construct 10 picnic sites and rehabilitate disturbed areas; construct a gravel access road and parking area with traffic control barriers. Future development[b] may include: construct 20 family campsites (10 of 20 RV) that could also function as a group campground; install accessible double-vault restroom, and hand pump water well with distribution system.*	Provide annual O&M. Contingent on acquisition of land for the facility.
J.C. Boyle bypassed reach access	*Construct two fishing access trails, trailheads, signs, single vault restroom, and pullouts below J.C. Boyle dam and near J.C. Boyle powerhouse[c].* *Construct boater put-in site below Boyle dam; provide sign; and graded gravel access road and parking area.* *Construct accessible fishing access platform near the J.C. Boyle powerhouse.*	PacifiCorp to develop joint management agreement with the Bureau of Land Management. PacifiCorp to provide annual O&M.
	Construct day-use area near 'old foundations area' with graveled parking area and turnaround; install accessible double-vault restroom. Construct trail between J.C. Boyle powerhouse and Spring Island Boater Access.	U.S. to own and Bureau of Land Management to administer day-use facility and trail and provide O&M.

Facility (Existing or *New*)	Recreational Improvements	Ownership, Operation and Maintenance
Stateline Take-out	Harden site (but do not expand footprint) to allow continued access and protect area resources; install traffic control barriers; relocate portable restrooms and provide changing rooms; PacifiCorp to correct the irrigation ditch seepage problem.	PacifiCorp and the Bureau of Land Management continue sharing O&M. PacifiCorp-owned lands to be included in the project boundary.
Fishing Access Nos. 1-6	Site 1: regravel access road and parking area; install interpretive sign and accessible double-vault rest room that may also be used as a changing room; construct an accessible fishing platform and short trail. Install traffic control barriers, particularly at Sites 1, 5, and 6. Provide formalized and hardened fishing access trails at Sites 2, 3, 4, and 5. Site 6: Manage as permit-only take-out and limit the number of whitewater boating take-out permits to five outfitters, when needed, harden to protect resources, and install accessible single-vault restroom.	PacifiCorp to continue providing O&M.
Dispersed site management	Boyle reservoir area: (1) Install traffic control barriers to restrict use in sensitive areas; (2) close, relocate, rehabilitate, and/or harden dispersed sites in sensitive areas, and (3) prioritize treatments in the Spencer Creek area. J.C. Boyle bypass and peaking reaches: Provide periodic site cleanup, enforce use policies on company-owned project lands, minimize fire hazards, as appropriate, and protect sensitive resources.	Coordinate dispersed use policies and actions with other land managers.

Note: Italicized text indicates new recreational sites or additions to existing recreational sites.

[a] Replaces Pioneer Park that is vacated due to Highway 66 Bridge realignment.

[b] Estimated at 10 years from license issuance.

[c] Proposed for PacifiCorp and/or the Bureau of Land Management to develop.

The Bureau of Land Management specifies that the RRMP: (1) include descriptions of and identify responsibility for O&M for the existing and proposed recreational sites and trails on Bureau-managed lands affected by the project, including Topsy Campground, Spring Island boater access, Klamath River Campground, dispersed day-use sites, and Stateline Take-out; and (2) provide funding for additional development and O&M at the J.C. Boyle bypassed reach boating and fishing access sites, associated access trails, and scouting trails at major rapids.

Interior recommends that PacifiCorp provide the following recreational improvements at the J.C. Boyle development: (1) a trail between J.C. Boyle and Copco reservoirs; (2) scouting trails at Caldera and Hell's Corner rapids; (3) a trail connecting Topsy Campground, Sportsman's Park, and Pioneer Park; (4) work with the Bureau of Land Management to design trails that provide universal access to fishing, wildlife viewing, and dispersed camping at appropriate sites; (5) trail access (to design standards for semi-primitive gradients) to access fishing sites and provide river access along the J.C. Boyle bypassed reach; (6) improve the hiking trail upstream of the parking area at the J.C. Boyle powerhouse to enhance fishing

and boating access; (7) develop several parking sites connected by a trail system along the powerhouse road; (8) a trail to connect with Klamath River Canyon dispersed sites; (9) replace a bridge across the Klamath River in the upper Frain Ranch at the location of the old bridge to provide pedestrian and administrative vehicle access; (10) design and locate the bridge and trails along the east side of the Klamath River that connect dispersed camping and fishing sites; and (11) a trail to connect the proposed upper J.C. Boyle boat access with an existing trail that provides access to the Keno reach.

In addition to the recreation proposals in the license application, Oregon Parks & Rec recommends that the RRMP include funding support to the Bureau of Land Management to: (1) provide O&M funding for and develop a potable water system at Topsy Campground; (2) provide O&M funding for and provide law enforcement at Frain Ranch; and (3) improve and maintain the whitewater-scouting trail at Caldera Rapid. Oregon Parks & Rec also recommends PacifiCorp construct a non-motorized trail between the J.C. Boyle powerhouse and Copco reservoir to connect dispersed camping, fishing, river access, and scouting sites.

Our Analysis

PacifiCorp's proposed recreational measures at the J.C. Boyle development would increase public access to project lands and waters, enhance recreational facilities, and provide additional recreational opportunities at this project development. All but two (discussed below) of the proposed measures for this development would be implemented during the first 10 years after license issuance.

Pioneer Park provides the most obvious point of access to the reservoir because it is located on Highway 66, a major thoroughfare. The footprint of this site overlapped with Oregon Department of Transportation's bridge replacement project and the resultant changes eliminated at least some of the facility components. Therefore, PacifiCorp would need to incorporate the footprint of the recently completed bridge into its revised plans for Pioneer Park. Although PacifiCorp formerly maintained a small day-use area on the east side of the bridge, the only proposed new or refurbished facilities are on the west side of the bridge. PacifiCorp estimates that the existing Pioneer Park use is below capacity and that any loss in capacity because of facility reconfiguration could result in use of this site meeting its capacity shortly after issuances of a new license. We consider it appropriate to include recreational access on both sides of the new bridge location since the topography is gentle and Highway 66 provides easy access to the project. This would provide abundant area for visitors on both sides of the bridge and would minimize the potential for user-created routes of access to the shoreline. We recognize that with the new bridge configuration, some of the former parking area on the east side of the bridge has been lost. However, based on our November 2006 observations of this site and as-built drawings of the bridge footprint provided by PacifiCorp by letter dated January 30, 2007, sufficient room exists for a small pull-off area, and the existing dirt-surfaced car-top boat launch, picnic table, and signage could be retained as a project recreational facility. This east side site offers much broader views of the expansive wetlands associated with J.C. Boyle reservoir than the west side site and would be ideal for wildlife viewing.

Additional development at the upper end of J.C. Boyle reservoir would provide recreational cartop boat access to the reservoir where such access does not currently exist, thereby opening more of the project lands and waters to recreational use. Besides creating new recreational access to the reservoir, this site could serve to absorb additional public day-use if and when Pioneer Park reaches its capacity (which is likely during the term of a new license based on expected population increases). Although the site would be located on land owned by PacifiCorp, the access road to this site would go through Sportsman's Park and the property of an adjacent private landowner. PacifiCorp would need to acquire an easement across private lands to provide public access to this potential site. Since this development would be a project recreational facility, it would be appropriate to include both the access road and the facility within the project boundary.

The proposed J.C. Boyle Bluffs campground and day-use area would provide another point of public access to the reservoir and provide a family campground that could also accommodate group use. This facility would provide about 10 additional overnight sites at the project and would meet a need for group use recreational facilities at the project that is documented in PacifiCorp's study results. As proposed, it would be constructed within the first 10 years following license issuance; however, the restroom and water system would not be installed until 20 years after license issuance. It is not clear to us why PacifiCorp would delay installing these important components and we consider it appropriate to install them as part of the site development within the first 10 years of the license.

PacifiCorp does not propose to include the Topsy Campground within the project boundary citing that the Bureau of Land Management constructed the site and is responsible for its O&M. Topsy Campground is located within the existing project boundary and provides a point of public access to the reservoir with a boat ramp, day-use facilities, and a fishing pier. Agency ownership and O&M of the facility do not provide sufficient rationale for us to support removing Topsy Campground from the project boundary. The Bureau of Land Management requested permission from the Federal Power Commission in 1962 to develop Topsy Campground. In response to this request, the Federal Power Commission noted that it wished "…to encourage all further recreational developments at the project which are practicable" (letter from J. Gutride, Secretary, Federal Power Commission, to State Director, Bureau of Land Management, Portland, Oregon, dated March 1, 1963). However, the Federal Power Commission requested that the Bureau of Land Management consult with the licensee regarding development of this facility and the completed facility was included in the project boundary. There is no evidence that management conditions have changed at this site since the Commission originally determined that this site served project purposes and should be included in the project boundary. Topsy Campground currently provides public access to project lands and waters, including a boat ramp and shoreline day-use facilities. The Bureau of Land Management seeks funding assistance for its management of this site but does not request that PacifiCorp manage it. The agency states the two water wells at the site have failed and there is a need to provide a reliable potable water supply. The Bureau of Land Management's desire to continue managing this site could be accommodated by including the site in PacifiCorp's proposed Operations and Maintenance Program whereby PacifiCorp proposes to develop memoranda of agreement with other entities to share recreation site administration. Including the site in the project license and establishing site management responsibilities with the Bureau of Land Management would ensure the site would continue to provide safe and adequate access to the reservoir. Topsy Campground is the only site on J.C. Boyle reservoir that currently provides developed campsites. Limited overnight camping is available at Sportsman's Park, but use is primarily for people participating in activities at the park (shooting, archery, OHV use, and model airplane facilities) not people using project lands and waters. Oregon Park & Rec's recommendation to provide a potable water system could be addressed through a memorandum of agreement that would define PacifiCorp's and the Bureau of Land Management's respective responsibilities.

Formal non-motorized trails do not currently exist in the vicinity of the reservoir. As proposed, the new loop trail would provide 5 miles of non-motorized trails for project visitors. This development would provide a new recreational opportunity, increase public access to the reservoir, and respond to the existing latent demand for trails that PacifiCorp identified in their recreation studies. As proposed, much of the trail would not be within the proposed project boundary[129] and may require PacifiCorp to obtain easements across one or more private parcels. If this trail were constructed as a license requirement, it would be necessary to review the trail location and make any necessary revisions to ensure the entire trail was included within the project boundary. This measure would be consistent with Interior's recommendation to construct a trail connecting the Topsy Campground, Sportsman's Park, and Pioneer Park. However, Sportsman's Park is currently not a project-related recreational facility, and there is no

[129]The proposed boundary excludes Topsy Campground and the trail passes through this site.

evidence that it serves project purposes because the park is enclosed by a fence that excludes the public from gaining access to J.C. Boyle reservoir. PacifiCorp's proposed trail alignment would pass close to Sportsman's Park at the Highway 66 Bridge, but we would have no basis to recommend that the trail provide pedestrian access to a non-project recreational facility.

PacifiCorp's proposed recreational enhancements at the J.C. Boyle bypassed reach would formalize existing user-created access routes and parking areas, as well as create new trails and fishing access. Formalizing the existing points of access would minimize the number of user-created routes leading to the river and prevent resource damage such as soil compaction and vegetation damage caused by indiscriminate parking along the roads. The proposed fishing platform near the J.C. Boyle powerhouse would enhance accessibility for persons with disabilities at the project. The two access trails to the bypassed reach would provide river access where formalized access does not currently exist. The proposed trails and day-use area (i.e., parking area and restroom) would accommodate recreation at the bypassed reach, which is within the existing and proposed project boundary.

PacifiCorp's proposed trail between the J.C. Boyle powerhouse and the Spring Island boater access would not provide project-related access (the peaking reach is not included in the existing or proposed project boundary). We question the need for such a short[130] trail and cannot determine a demonstrated project-related need for this trail (i.e., no identified recreation-related effects or visitor demand). We also note that parking would be provided at both ends of this proposed trail so there does not appear to be a need for a route of travel between the two sites. If this site were constructed as a license requirement, PacifiCorp should enter into an agreement as part of the Operation and Maintenance Program to identify their responsibilities prior to initiating this development.

PacifiCorp's proposal to manage dispersed recreational use at this development would continue to provide dispersed day and overnight use while minimizing the documented effects on natural resources such as wildland fire, vegetation damage, bare and compacted soil, and pollution. PacifiCorp's proposed measures to close, harden, and/or monitor certain sites near sensitive resources, and provide site closure enforcement are consistent with the Bureau of Land Management's 4(e) condition.

In the peaking reach there would be continued public access to project waters and lands within the project boundary and enhancements would be provided at the Stateline Take-out and the six fishing access sites. PacifiCorp's study results and comments filed in Interior's March 27, 2006, letter to the Commission document maintenance needs for roads, restrooms, signage, and gates. Our observations during our site visit to the project area confirm that these sites are in need of maintenance. This need for maintenance, combined with considerable high levels of recreational use, support the need to reconstruct these sites to provide safe and adequate project recreational facilities. PacifiCorp's proposed redesign, reconstruction and O&M of these sites would meet this need and address existing effects on sensitive resources. Proposed new facilities would provide amenities such as a changing room[131] and improved restrooms to whitewater boaters who use the peaking reach. PacifiCorp's proposal to make capital improvements and provide O&M is consistent with agency conditions and recommendations.

We agree that if a PacifiCorp irrigation canal is leaking onto Bureau of Land Management-managed land, as the conceptual design for the proposed Stateline Take-out recreational enhancements indicates, it should be repaired. Interior, in its December 1, 2006, filing commenting on the draft EIS, states that the leaking irrigation canal primarily affects the PacifiCorp portion of the Stateline Take-out site because vehicle access on the access road is compromised and resource damage occurs because of the

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[130]Staff estimates the length of the trail would be about 0.25 mile.

[131]We note the specific wording in the draft RRMP describes this structure as 'above-ground' changing room. Staff assumes this is a building with a foundation, walls and roof and we do not understand the significance of the term 'above-ground'.

resultant muddy conditions. Consequently, it would be appropriate to include repair of this irrigation canal as a condition of any license that may be issued for this project, unless repairs are completed and documented prior to license issuance.

We do not find several of the agency conditions and recommendations to have a project nexus. The Spring Island boater access, Klamath River Campground, Frain Ranch, dispersed sites, and whitewater scouting trails along the peaking reach do not provide access to project lands or waters or accommodate project recreation, nor are these sites located within the project boundary. Public access for kayakers and small rafts would be accommodated by PacifiCorp's proposed angler and boater access sites at the upper and lower ends of the bypassed reach. Most commercial rafters would still likely use the Spring Island boater access. Several of the trails recommended by Interior, Oregon Fish & Wildlife, and Oregon Parks & Rec are included in PacifiCorp's proposal as previously indicated; however, the recommended trail from the proposed Upper J.C. Boyle boating access to an existing trail along the Keno reach would primarily access non-project waters. Similarly, the agency-recommended trail between the J.C. Boyle powerhouse and Copco reservoir in the project license would not provide access to project waters. We conclude that the proposed 5-mile loop trail around the reservoir would meet the need for additional trails at this development.

Copco Development. PacifiCorp proposes improvements at existing recreational facilities and constructing new recreational developments as listed in table 3-97. PacifiCorp's proposals for owning, operating, and maintaining the recreational facilities and managing dispersed recreational use are also indicated in the table.

Table 3-97. PacifiCorp's proposed recreational improvements at Copco development. (Source: PacifiCorp, 2004j, as modified by staff)

Facility	Recreational Improvements	Ownership, Operation and Maintenance
Mallard Cove	Redesign and reconstruct site to include: 10 family campsites, two accessible double-vault restrooms and; a separate day-use area at the point (north of existing parking area) with five picnic sites, shade trees, and/or shelters and an accessible fishing access pier adjacent to the boat launch.	PacifiCorp to provide O&M for this site.
Copco Cove	Redesign and reconstruct boat ramp access and parking area and gravel the parking area; repair (regrade) and replace three picnic sites; install an accessible single-vault restroom.	Close this site to overnight use and enforce closure. PacifiCorp to provide O&M for this site.
Copco Reservoir Shoreline	Prohibit all overnight camping at dispersed use areas.	PacifiCorp to provide O&M and enforcement.

Our Analysis

There are only two small parcels of land that are not privately owned at this reservoir shoreline and these are the only two points of public access to the reservoir. These sites have a nexus to project purposes because they provide boating and fishing access to the reservoir. As previously discussed in the affected environment section, use of both sites is currently below capacity not because of low demand but because of visitor perception that both sites do not offer optimal recreational opportunities. PacifiCorp's studies documented a need to separate the existing overlapping day and overnight use occurring at these small sites and install new infrastructure to address health and safety concerns with the aging site components. Mallard Cove, located on the southern shoreline with paved road access, is a gentle sloping

site where it would be possible to create distinct and separate facilities for day and overnight use. Developing such facilities, as PacifiCorp proposes, would ensure overnight users would not displace day users at the limited shoreline available for public access. We also note that the gentle slopes would be compatible with providing accessible facilities such as the proposed fishing pier.

Copco Cove is a small site with steep slopes so it may not have sufficient area to develop separate day and overnight areas. PacifiCorp's studies document soil erosion and a need for improvements to the parking area, access road, and restroom. Access to this area is by way of about 5 miles of native-surfaced road, which appears to limit the number of visitors who use this site. Consequently, PacifiCorp's proposal to convert this site seems appropriate so that overnight users would not displace the few day-use visitors who come to this area. Developing a designated area for camping at Mallard Cove would accommodate overnight users who could be displaced by the changed conditions at Copco Cove. Eliminating overnight use at Copco Cove may also reduce some of the documented harmful effects, such as vegetation removal that is likely related to campfire use.

PacifiCorp's proposed measures for developed recreational facilities at the Copco development would enhance these facilities. The existing deteriorated conditions (documented in PacifiCorp's study results and viewed by staff) and visitor displacement occurring at both of these sites support the need for redesign and reconstruction within the first 10-year period after license issuance. We note that the existing project boundary includes the Copco Cove site but not Mallard Cove site. If these facilities were included in the project license, it would be appropriate to include both of them within the project boundary, as proposed by PacifiCorp.

PacifiCorp only identified two dispersed use areas along the Copco reservoir shoreline. It documents moderate ecological effects in the form of bare and compacted soil that it speculates is more related to grazing practices than recreational use. Regardless of the source of the damage, it would be appropriate to include measures, as PacifiCorp proposes, to correct practices occurring within the project boundary that could contribute sediment to the project reservoir from erosion. The number of displaced visitors affected by instituting site closures would be negligible since there are only two sites.

Fall Creek Development. PacifiCorp proposes improvements at existing project recreational facilities and constructing new recreational developments listed in table 3-98. PacifiCorp's proposals for owning, operating and maintaining the recreational facilities and managing dispersed recreational use are also indicated in the table.

Table 3-98. PacifiCorp's proposed recreational improvements at Fall Creek development. (Source: PacifiCorp, 2004j, as modified by staff)

Facility (Existing or *New*)	**Recreational Improvements**	**Ownership, Operation and Maintenance**
Fall Creek Trail	Harden the trail to the falls *and extend to create a loop trail*; construct a graveled trailhead and install a sign along Copco Road outside gate and hatchery area or near the existing parking area; install fencing to restrict public access near hatchery and hydro facilities.[a]	Cal Fish & Game and PacifiCorp to share O&M. PacifiCorp to operate the site if Cal Fish & Game vacates the site.

Note: Italicized text indicates new recreational sites or additions to existing recreational sites.

[a] Proposed as PacifiCorp and/or Cal Fish & Game to develop

Our Analysis

This recreational site has closed gates and restrooms and deteriorated parking areas, trail surfaces, gates, and signs, based on our site visit observations: it appears the recreational amenities have been abandoned. PacifiCorp proposes to redesign, expand, and reopen the site. PacifiCorp determined that the existing use of the recreational facilities is below capacity, not because of lack of demand, but because of visitor perception that this area does not offer optimal recreation opportunities. However, PacifiCorp suggests sharing site development and O&M responsibilities with Cal Fish & Game. The proposed day-use area and trail would provide an appropriate degree of public access to project lands and waters. We note that this is the only existing non-motorized trail opportunity available for visitors to the Iron Gate reservoir area. We conclude that the presence of structures related to the project, the city of Yreka's domestic water diversion, and the fish hatchery require clearly defined areas where the public can safely recreate. Because PacifiCorp states it would take over the site if Cal Fish & Game vacates it, including this development in the project boundary would ensure it would continue to provide safe public recreational access adjacent to a project feature. PacifiCorp could explore sharing O&M responsibilities through its proposed Operations and Maintenance Program. Although Cal Fish & Game currently is not operating this hatchery facility, in the event it is reopened, Cal Fish & Game may elect to include public observation areas where hatchery operations could be viewed. In this case, some shared operation and maintenance responsibilities could be appropriate. However, given that this is the only recreational site at this project development and PacifiCorp already owns the land on which the proposed trail and day-use area would be located (as well as the land on which the hatchery is located), we consider it appropriate for PacifiCorp to ultimately be responsible for operation and maintenance of this site. The footprints of the proposed trail and day-use facilities are within the proposed project boundary; however, if the trail were constructed under a new project license, its location should be verified and PacifiCorp should adjust the project boundary, if necessary, to include all of the as-built trail and associated amenities.

Iron Gate Development. PacifiCorp proposes improvements at existing project recreational facilities and constructing new recreational developments as listed in table 3-99. PacifiCorp's proposals for owning, operating and maintaining the recreational facilities and managing dispersed recreational use are also indicated in the table.

The Forest Service and Interior recommend that PacifiCorp improve river access sites in the Middle Klamath Reach between Iron Gate dam and Happy Camp during the peak recreational season, including maintenance and improvements at three river access sites:[132] (1) below Iron Gate dam; (2) near I-5; and (3) at the Klamath River confluence with Indian Creek. Interior states that the project has created stable and reliable flows which have led to increased whitewater boating and fishing use. Interior's rationale for the recommendation is, "the need to protect and enhance this WSR designated river segment…and help support achievement of the environmental justice goals for economically disadvantaged communities and populations."

[132]Interior recommends improvements at all three sites. Forest Service only recommends improvements at the Klamath River confluence with Indian Creek.

Table 3-99. PacifiCorp's proposed recreational improvements at Iron Gate development. (Source: PacifiCorp, 2004j, as modified by staff)

Facility (Existing or *New*)	Recreational Improvements	Ownership, Operation and Maintenance
Fall Creek (at confluence with Iron Gate reservoir)	Close and restore site to protect sensitive resources. Remove existing infrastructure except for the boat ramp. Allow use only for special events.	PacifiCorp to O&M this site.
Jenny Creek Day-use Area and Campground	Close and restore site to protect sensitive resources. Remove existing infrastructure and install accessible single vault restroom. Construct a graveled pullout area along Copco Road adjacent to existing site with a trail leading to the restroom.	PacifiCorp to O&M this site.
Wanaka Spring Day-use Area	Redesign and reconstruct a fee-only group reservation camp with 10 to 12 RV/tent campsites, including shade trees and/or shelters; install two accessible double-vault restroom buildings; regrade and regravel the access road and parking areas and provide traffic control barriers; provide a central group shelter; install a hand pump water well.	PacifiCorp to O&M this site.
Camp Creek Day-use and Campground	*Construct campground with about 40 family campsites on the upper bench area behind the existing restroom*; install 4 accessible double-vault restrooms; convert existing shoreline camping area to a 12-site day-use area; provide additional shade trees (including irrigation) and/or covered picnic tables in day-use picnic areas; construct a formalized overflow parking area with traffic control barriers; construct gravel access roads to both the adjacent private properties and the new campground; provide accessible improvements at the hand boat launch area and convert this area to a day-use site; repair or replace the existing dock and ramp; provide 5-10 mooring balls for temporary boat moorage near the boat launch; extend the water system to the new camping area; provide 5-10 boat moorage slips near the boat launch.	PacifiCorp to O&M this site. When the improvements have been completed, PacifiCorp would implement a fee-only camping policy.
Juniper Point Day-use and Campground	Redesign the site for day-use picnicking only (nine sites)[a]; redesign and reconstruct the access road; replace the existing restroom with an accessible double-vault restroom on the reservoir side of Copco Road; plant shade trees and/or shelters at picnic sites.	PacifiCorp to O&M this site.
Mirror Cove Day-use Area and Campground	Redesign and convert the area not associated with the boat launch area to a reservation-only group campground (about 10 sites)[b]. Retain boat launch area and provide: two accessible double-vault restrooms on the reservoir side of Copco Road; five picnic sites next to the boat launch; 5-10 mooring balls for temporary boat moorage; accessible improvements to the boat launch and new boarding docks. Relocate the boat ramp to a deeper area adjacent to the existing ramp or dredge the existing ramp area and extend the ramp lane. Plant shade trees and/or shelters at all camping and day-use sites and install a hand pump water well.	PacifiCorp to O&M this site.

Facility (Existing or *New*)	Recreational Improvements	Ownership, Operation and Maintenance
Long Gulch Day-use Area and Campground	Redesign, reconstruct and convert to day-use only facility[a] with five new day-use sites with additional shade trees (including irrigation) and/or covered picnic shelters for each site; provide 5-10 mooring balls for temporary boat moorage; formalize existing graveled parking area, provide an overflow parking area and install traffic control barriers. Construct a trailhead for the Long Gulch to Iron Gate Hatchery trail (described later). Provide accessible improvements to the boat launch and new boarding docks; expand the boat ramp to two lanes when this capacity is needed.[c]	PacifiCorp to O&M this site.
	Construct a new 40-site fee campground adjacent to the existing boat launch[e]. Provide: gravel-surfaced roads and centralized potable water; three accessible double-vault restrooms; a non-motorized trail between the campground and the boat launch with overlook areas; a shoreline day-use area at a nearby cove with parking and accessible double-vault restroom.[d]	PacifiCorp to O&M this site.
	Construct a 1-mile, multiple-use, native-surfaced trail between Long Gulch and Iron Gate Hatchery on an old roadbed; *improve an existing 0.5-mile trail along Bogus Creek and provide signage*.	
Overlook Point Day-Use Area	Close site to overnight use and vehicular access and redesign and reconstruct this area as a boat-in day-use only site (three sites). Provide additional shade trees (including irrigation) and/or covered picnic tables at each of the three sites and; one accessible single-vault rest room in place of the existing restroom.	PacifiCorp to O&M this site.
Iron Gate Hatchery	Redesign the day-use area and provide additional shade trees (including irrigation) and/or covered picnic tables at picnic sites; and a trailhead for the proposed Bogus Creek and Long Gulch to Iron Gate Hatchery trails, with signage. Harden the access road to the existing river boat launch adjacent to this site.	Cal Fish & Game would provide annual O&M.
Iron Gate Reservoir Shoreline	Prohibit all overnight camping at dispersed use areas.	PacifiCorp to provide O&M and enforcement.

Note: Italicized text indicates new recreational sites or additions to existing recreational sites.

[a] Gradually phase out overnight use of this site as the Camp Creek campground expansion is completed and direct overnight visitors to the Camp Creek Recreation Area or the Long Gulch Bluff recreation area (when completed).

[b] Non-group overnight visitors would be redirected to Camp Creek or Long Gulch Bluff recreation areas, when completed.

[c] Estimated at 15 years from license issuance.

[d] Contingent on documented level of use at the Camp Creek Recreation Area based on monitoring results. PacifiCorp estimates this would occur about 20 years from license issuance.

Our Analysis

The primary factors we considered in evaluating PacifiCorp's proposed developments at Iron Gate reservoir include (1) instances of recreational use is harming sensitive resources; (2) existing use levels indicating additional day and overnight capacity is needed; (3) areas within a facility being used for both day and overnight without separation of these uses; (4) facilities designed for only day-use activities receiving overnight use; and (5) in general, PacifiCorp's studies, which our site visit observations confirm, documenting that there are maintenance needs and accessibility deficiencies at all of these facilities related to roads, parking areas, signage, restrooms, boat launches and fishing/boarding docks. As indicated in table 3-94, use of the existing recreational facilities at Iron Gate reservoir is approaching, at, or exceeding capacity. Recreational demand is likely to increase during the term of a new license. Consequently, the need for increased recreational opportunities at this development is evident.

PacifiCorp appropriately proposes to close the Jenny Creek and Fall Creek areas to reduce recreation-related effects on sensitive resources. Closing these sites would eliminate about nine of the 59 developed sites[133] at Iron Gate reservoir. This decrease would be more than compensated by PacifiCorp's proposed development which would create about 97 sites within the first 10-year phase of the license and potentially add about 40 more sites in the second 10-year phase of the license at Iron Gate reservoir.

We consider the optimal arrangement for providing public access to project waters to consist of designating shoreline areas for day-use and locating campgrounds upslope and adjacent to these areas, as PacifiCorp proposes. In addition, PacifiCorp's proposal would (1) meet the need to increase the developed capacity at the reservoir by planning for two additional 40-site campgrounds; (2) meet the need for providing group use recreational facilities by redesigning and reconstructing the Wanaka Springs and Mirror Cove areas; (3) meet the need to provide trails by constructing two trails; (4) provide accessible recreational facilities by redesigning and reconstructing existing facilities including boat ramps; and (5) provide for public health and safety needs by replacing deficient infrastructure (e.g., restrooms, access roads). PacifiCorp appropriately places a priority on the existing sites and use patterns by proposing to complete improvements at the existing developments within the first 10-years of license issuance. PacifiCorp's proposal to provide moorings for temporary boat moorage would minimize effects on shoreline vegetation by providing visitors an alternative place to tie up their boats. An adaptive approach for developing additional facilities at Long Gulch tied to recreational use triggers at existing facilities at Iron Gate reservoir, as PacifiCorp proposes, seems to us to be particularly appropriate. If summer algal blooms that have occurred during recent years continue to persist under a new license, the planned increased recreational capacity may not be needed, as the public may seek alternative locations.

PacifiCorp only identified four dispersed use areas along the Iron Gate reservoir shoreline. It documents moderate ecological effects in the form of bare and compacted soil that it speculates is more related to grazing practices than recreational use. Regardless of the source of the damage, it would be appropriate to include measures, as PacifiCorp proposes, to correct practices occurring within the project boundary that could foster erosion and contribute sediment to the project reservoir. The number of displaced visitors affected by instituting site closures would be negligible considering there are only four areas. Additionally, PacifiCorp's proposed improvements to the developed sites and additional capacity would likely accommodate any visitors displaced by the closures. We consider the Iron Gate Hatchery day-use area to be a project-related recreational facility and as such it would be appropriate for O&M to ultimately be PacifiCorp's responsibility.

The Forest Service and Interior recommendations are not supported by a demonstrated project-related effect, and the recommended sites at I-5 and the Indian Creek confluence with the Klamath River are about 8 and 50 miles downstream of the most downstream extent of the project boundary,

[133] We cannot provide analysis in terms of overnight and day-use capacity because both types of use occur at most of the sites.

respectively. Consequently, these sites would not provide access to project lands and waters. We recognize there may indeed be river recreational use occurring at these locations. However, we consider this activity and any associated effects would occur irrespective of the project and we cannot find a nexus between these sites and the project. PacifiCorp proposes to make improvements to river access near the Iron Gate Hatchery and this is consistent with Interior's recommendation and would provide public access to project lands and waters.

Recreation Management-Programmatic Elements

The draft RRMP outlines eight programs that would be used to manage project recreational resources. We discuss the Whitewater Boating and River-Based Fishing Program in section 3.3.6.2.2, *River Recreation*. The Recreation Facility Development/Capital Improvement Program is discussed in the preceding subsection, *Recreational Facility Development* and the Aesthetic/Visual Resource Enhancement Program is discussed in section 3.3.7, *Land Use and Aesthetic Resources*. The reader is referred to the draft RRMP for a detailed description of the remaining five programs which include (1) Recreation Operations and Maintenance Program, (2) Recreation Monitoring Program, (3) Resource Integration and Coordination Program, (4) Plan Review and Update Program, and (5) Interpretation and Education Program. The following text discusses these five proposed programs with analysis of the agency terms, conditions and recommendations included as they pertain to each of these programs.

Recreation Operations and Maintenance Program. Under this program PacifiCorp would define its O&M responsibility for developed and dispersed recreational sites, establish maintenance standards, propose cost-sharing arrangements with other entities (both capital and O&M) and provide funding assistance for land- and/or water-based law enforcement. In its comments on the draft EIS, PacifiCorp indicates that provisions for recreation site facility replacement are included as an element of its Recreation Resources Management Plan, and this would be clarified in the next version of the Plan.

PacifiCorp proposes to provide seasonal resource protection and visitor management control by providing a PacifiCorp Park Ranger to patrol all project recreational sites and reservoir shorelines by vehicle from May through October.[134] PacifiCorp also proposes to seek a contract with the Siskiyou County Sheriff's Office or other appropriate entity, for land-based law enforcement patrols[135] of project lands from Iron Gate Hatchery upstream to Stateline Take-out from May through October.

The Bureau of Land Management specifies that the final RRMP would include the estimated O&M costs, identify the appropriate instrument for shared administration of Bureau of Land Management sites, and include provisions for working with the Bureau to define standards for facility O&M, replacement, modification, or upgrade. It also specifies that the RRMP would include provisions to bring facilities up to Bureau of Land Management standards for accessibility, public health and cleanliness, safety, and security.

Oregon Parks & Rec recommends that PacifiCorp provide funding for O&M and law enforcement at Frain Ranch. Interior recommends that PacifiCorp (1) negotiate an agreement to fund the Klamath County Sheriff's Department to retain a land-based deputy for 4 to 6 months to patrol Project roads; (2) negotiate an agreement to fund the Klamath County sheriff's department to retain a part-time water-based deputy to patrol J.C. Boyle and Keno reservoirs during periods of peak recreational use (mid-

[134]PacifiCorp would coordinate its patrols with the Bureau of Land Management and Klamath County law enforcement patrols in J.C. Boyle reservoir and J.C. Boyle bypassed reach to maximize management presence and coverage, address changing visitor management needs, provide backup coverage when needed, and better enforce new dispersed site use restrictions.

[135]Siskiyou County Sheriff's Office would continue to provide California Department of Boating and Waterways-funded marine patrols.

May through October); (3) fund the operation of a 4-wheel drive vehicle to patrol the project area; (4) fund a communications firm to analyze the feasibility of establishing and improving an emergency/early warning system; and (5) increase on-river patrols and management presence in the Middle Klamath Reach between Iron Gate dam and Happy Camp during the peak recreational season. The Forest Service also recommends PacifiCorp provide funding for increased on-river patrols.

Our Analysis

As proposed, the Operation and Maintenance program identifies PacifiCorp's ultimate responsibility to operate and maintain project related recreational facilities and dispersed use sites. This program also provides a means to explore sharing development and O&M costs with other entities that have overlapping ownership or management responsibilities with project recreational facilities. Although other entities have recommended PacifiCorp provide O&M funding for Frain Ranch, Klamath River Campground, and Spring Island boater access, we do not find these areas have a project nexus (see subsection, *Recreational Facility Development*). Upper Klamath Outfitters Association, commenting on the draft EIS in a letter dated November 24, 2006, state that it currently pays 3 percent of its gross receipts from commercial trips on the Upper Klamath River to the Bureau of Land Management. We presume that at least a portion of these revenues could be either directly or indirectly (through budget allocations to the Bureau of Land Management) applied to O&M of Spring Island. If this site should become PacifiCorp's responsibility, as specified in the modified 4(e) condition, we conclude that PacifiCorp would be entitled to collect fees for O&M of this site that would otherwise have been expended by the Bureau of Land Management.

PacifiCorp provides an appendix to the draft RRMP that outlines maintenance standards for project recreational facilities. These appear to provide sufficient guidance to result in safe and suitable public recreational facilities. Since some of the project recreational facilities[136] overlap with other agency jurisdictions, it would be appropriate to develop and agree upon these standards in consultation with these other agencies. In response to the draft EIS, PacifiCorp states that Recreation Work Group participants, including neighboring agencies, were invited to participate in the development of the draft Recreation Resources Management Plan and members of this group would continue to be involved in developing the final plan. All consultation with Work Group participants would be documented in the final RRMP.

PacifiCorp's draft RRMP outlines plans for designing, upgrading, constructing and providing O&M for several developments. However, the draft plan does not yet specifically address the need to replace the facilities during the term of the license. We expect that PacifiCorp's O&M responsibilities would include replacement of facilities on an as-needed basis. PacifiCorp, in its comments on the draft EIS, concurs.

PacifiCorp proposes and several of the agencies recommend funding support for law enforcement at the project. We consider PacifiCorp's property tax payments and fees paid for occupying federal lands fulfill its obligation and we do not find any rationale that support the need to augment agency funding for these services. The Commission would not object to PacifiCorp's proposal to explore agreements with law enforcement agencies; however, it would not be an appropriate measure to include in the project license for the reason stated.

PacifiCorp's proposal includes project area patrols which are consistent with the portion of Interior's recommendation to provide 4-wheel drive patrol of the project area. The draft RRMP does not include a component to address OHV use at the project. Considering the growing popularity of this activity, we consider it to be appropriate to include a plan to manage this use as either a component of the

[136]The Bureau of Land Management has an interest in Topsy Campground and Stateline take-out, Pioneer Park is adjacent to the right-of-way for Highway 66 and Cal Fish & Game has an interest in the facilities at Fall Creek and Iron Gate fish hatchery.

final RRMP or the proposed Road Management plan (see section 3.3.7.2, *Land Use and Aesthetic Resources*). This would help ensure this activity would not harm sensitive resources at the project.

Interior's recommendation for PacifiCorp to conduct a feasibility analysis for the potential establishment of an early warning system is designed to enable notification of public agencies and commercial whitewater boating outfitters in the event of an emergency at the J.C. Boyle dam or powerhouse. In its rationale statement, Interior points out that within the Klamath River Canyon, there is limited telephone and radio reception, which could prevent notification of recreationists within the peaking reach and emergency responders of unexpected hydropower release changes, wildfires, law enforcement emergencies, and medical emergencies.

At a project where whitewater boating use is dependent on scheduled releases, such as the J.C. Boyle peaking reach, unanticipated interruption of scheduled flows and the resultant decrease in water level could result in boaters being stranded at relatively remote locations (the distance between the Spring Island put-in site and the State-line takeout site is 11 miles). If communication with support personnel or emergency responders is not possible, public safety could be jeopardized. Consequently, assessing the feasibility of enhancing communications along portions of the peaking reach where it is currently limited can be viewed as having a nexus to project purposes. If it is demonstrated to be feasible to enhance communications, we consider it inappropriate for PacifiCorp to be responsible for all implementation costs. Notification of whitewater boaters of risks associated with wildfires and law enforcement emergencies and the potential need for whitewater boating outfitters to notify emergency responders of medical emergencies is not, in our view, a project-related need. Consequently, if enhanced communications are shown to be feasible, implementation of a cooperative funding agreement with other entities would be appropriate. Details of any such agreement could be included in the periodic updates of the RRMP that PacifiCorp proposes.

Recreation Monitoring Program. Under this program PacifiCorp would identify monitoring indicators and standards, and establish the locations and frequencies that would be used to collect various types of monitoring data. PacifiCorp proposes, in general, to conduct visitor surveys every 12 years; monitor recreational use effects annually; monitor dispersed site conditions and flatwater boating use every 6 years; determine visitor use levels every 6 years; and determine whitewater boating use levels every year.

The Bureau of Land Management specifies that the final RRMP include provisions for working with the Bureau to define standards for monitoring. Further, the Bureau specifies the final RRMP include provisions for monitoring visitor use on Bureau lands affected by the project at an interval no greater than 5 years and establish trigger points for adaptive management. They also specify that PacifiCorp develop and provide a visitor-use report to the Bureau of Land Management and the Commission.

Our Analysis

Recreational needs at the project would likely change over the term of any license in response to growing population, and changes in user preferences, technology, and use patterns. PacifiCorp has proposed a satisfactory approach to providing data that would reveal these potential changes through the term of the license. PacifiCorp's proposed monitoring scheme coincides with the Commission's Form 80 requirement to report on recreational use at the project every 6 years and we recognize there are cost benefits to synchronizing these two efforts. The Bureau of Land Management has not provided rationale explaining why the 6-year reporting frequency does not meet the agency's needs or identified a specific existing or potential condition that would create the need to monitor more frequently. We do not find a material difference between the two monitoring frequencies, and there would be cost efficiencies gained by synchronizing PacifiCorp's monitoring effort with the Form 80 reporting schedule. Providing the visitor use report to the Bureau of Land Management, as the agency specifies, could be accommodated by including this provision in the final RRMP.

Resource Integration and Coordination and Plan Review and Update Programs. PacifiCorp would convene annual meetings with other recreation providers, agencies, and other stakeholders in the project area. The following entities would be invited to participate: The Bureau of Land Management, Forest Service, Oregon Park & Rec, National Park Service, Klamath County, Siskiyou County, Oregon Fish & Wildlife, Cal Fish & Game, whitewater outfitters, and other private groups, as needed. These meetings also would be used to discuss and prioritize future project recreational improvements. PacifiCorp proposes to solicit advisory input from the above-listed entities and create a 5-year action plan to document recreation-related activities for the prior year and upcoming year and planned developments for the following 3-year period. PacifiCorp would make this action plan available for public review after it is completed.[137]

PacifiCorp would track and document necessary changes to the plan on an annual basis and amend the plan, if necessary. PacifiCorp would complete a formal review the RRMP every 6 years and revise the plan every 12 years, if needed.[138] The Bureau of Land Management specifies that the final RRMP should include provisions for annual review and modification of the plan.

Our Analysis

PacifiCorp proposes to provide an opportunity for stakeholder involvement in ongoing recreational planning in section 4.5 of its draft RRMP which describes annual meetings of an advisory committee. Considering there are multiple entities with recreation management responsibilities and interests at the project, PacifiCorp proposes a reasonable approach to involve other entities to coordinate planned operations and site development.

We are concerned that the 5-year rolling plan approach proposed by PacifiCorp in this RRMP program may not provide an adequate notice and planning horizon for recreational development at the project. Specifically, we note that PacifiCorp would solicit input from the advisory committee to formulate plans for the ensuing 3 years and include this information with the current year's planned operation. In our view, a longer[139] planning period should be provided in the action plan to reveal potential conflicts so that they could be avoided. This would ensure visitor use is accommodated during construction and reconstruction at recreational developments. In addition, PacifiCorp indicates it would seek cost sharing with other entities for development and O&M costs. Agencies go through lengthy processes to secure capital improvement funding and a longer planning period would accommodate this potential circumstance. Additionally, some of the planned development may require closing sites during the recreational season which could displace visitors. We consider a 10-year planning horizon, with an annual review as PacifiCorp proposes, to appropriately accommodate these circumstances.

PacifiCorp's proposed approach for periodic plan reviews and updates would enable the RRMP to reflect changes in recreational use patterns, address plan deficiencies that may not have been evident during final RRMP development, and accommodate any changes in agency management direction that may occur during the term of a new license. We consider PacifiCorp's proposed measure to be consistent with this aspect of the Bureau of Land Management's preliminary 4(e) condition.

Interpretation and Education Program. PacifiCorp proposes to, within 1 year of license issuance, develop and implement a detailed interpretation and education plan in consultation with a working group

[137]This information is provided in section 4.5 of the draft RRMP. We assume this to mean the public would be able to receive an informational copy of the action plan; however, PacifiCorp would not provide a formal opportunity for public input to develop the action plan.

[138]At the 12-year review, the document would be reprinted if changes were made during the previous two 6-year review periods.

[139]A period longer than the 4-year period described in the program.

formed from the entities participating in the annual coordination meetings (see Recreation Integration and Coordination Program). The draft RRMP states that PacifiCorp, as part of the Interpretation and Education Program, would design, place, and provide O&M for about 25 signs or small kiosks within the project area, develop visitor brochures, and provide campfire talks.

Interior recommends that PacifiCorp develop an interpretation and education program for the project in consultation with the Bureau of Land Management. The plan would identify interpretive opportunities, including brochures, and signage needs at recreational sites, project facilities, and along project roads. Interpretive kiosks would be considered for Topsy Road, Highway 66, and other major thoroughfares. The plan would address monitoring and maintaining these facilities. It also would include provisions for developing information specific to health and safety, public access, OHV use, illegal dumping, and use of firearms, as well as information regarding public service announcements and early warning systems to provide real-time flow information for the Boyle bypassed and Keno reaches.

Our Analysis

The proposed Interpretation and Education program would (1) improve public access to project recreational facilities by providing directional signs; (2) promote responsible recreational use (e.g., litter reduction, boating use) to minimize harmful effects on sensitive resources at the project; (3) meet the existing high demand for information and education-related activities in the region; (4) repair or replace deficient information-related infrastructure; and (5) update information that is currently provided.

Although PacifiCorp proposes measures under this program that would be undertaken within the project boundary, the benefits of this program would extend to the region, as a whole. Accordingly, developing this program in consultation with other agencies that provide recreational facilities and programs in the region would maximize public benefit. This coordination would provide consistency within the region. Developing this program in consultation with the Bureau of Land Management and others, as PacifiCorp proposes, would be consistent with Interior's recommendation.

Access to Project Lands and Waters

Oregon Fish & Wildlife recommends that PacifiCorp allow the public free access to project water and adjacent project lands owned by the licensee, with the exception that access by motorized vehicles would continue to be restricted during the critical winter period per the Pokegama cooperative road closure agreement.

Our Analysis

PacifiCorp would be required under a standard license condition to allow reasonable public access to project lands and waters for recreational purposes. This condition appears to accommodate Oregon Fish & Wildlife's objective to provide full public use of such lands and waters for outdoor recreational purposes, including wildlife viewing, angling, and hunting. However, we note the recommendation specifically states, "free access" which, if included in the project license could have two types of implications: (1) unobstructed access; or (2) access without charge. First, access to project lands should consider closures to protect sensitive resources and restrictions to prevent the public from entering unsafe areas. Second, licensees are allowed to collect reasonable fees to recover O&M cost associated with providing recreational facilities. Requiring PacifiCorp to allow "free access" to project lands would not allow the licensee to institute closures to protect sensitive resources or recoup administrative costs, as allowed by the Commission.

3.3.6.2.2 River Recreation

This section includes an analysis of the flow related measures that affect river-based recreational activities at the project. We analyze PacifiCorp's Whitewater Boating and River-based Fishing Program

included in the draft RRMP and the flow measures proposed by PacifiCorp and presented in the stakeholder terms, conditions, and recommendations. Detailed descriptions of the flow measures are provided in section 3.3.3.2.1, *Instream Flows*.

Whitewater Boating and River-based Fishing Program

The draft RRMP program outlines PacifiCorp's proposal to make capital improvements to and provide O&M for recreational facilities related to whitewater boating and angling use (these measures are discussed in the *Recreational Facility Development* subsection of 3.3.6.2.1, *Recreation Resource Management*), operate the project in a manner to provide flows suitable for whitewater boating, and provide flow information.

PacifiCorp proposes to increase flows in the J.C. Boyle peaking reach to a minimum of 1,500 cfs[140] by noon on Sundays, Mondays, Tuesdays, Thursdays, and Fridays and by 10:00 a.m. on Saturdays; there would not be a set schedule for Wednesdays. PacifiCorp states that operating two units (2,525 cfs) would likely occur less often and the daily flow variation would not exceed 1,400 cfs from the J.C. Boyle powerhouse in a 24-hour period. Ramping would not exceed 9 inches per hour. If flows are less than 1,000 cfs then ramping would not exceed 4 inches per hour. PacifiCorp proposes to release minimum instream flows below Iron Gate dam to comply with the NMFS BiOp (see table 3-23). Under these requirements PacifiCorp would release between 1,000 to 3,025 cfs, below Iron Gate dam, depending on the month of the year and water year type. PacifiCorp would also continue to provide flow information through a toll-free telephone number and via the project website.

Oregon Parks & Rec recommends PacifiCorp develop a whitewater boating opportunity within the J.C. Boyle bypassed reach, which would be coordinated with geomorphic seasonal high flow events to allow for a stable run on the rise or fall of the hydrograph. This opportunity would be developed in collaboration with stakeholders within 1 year of license issuance.

The Bureau of Land Management modified 4(e) condition specifies weekly peaking to provide flows in excess of 1,500 cfs in the peaking reach for whitewater rafting while still maintaining the specified minimum flows to the bypassed reach and the 2-inch-per-hour ramping rates downstream of the powerhouse. The specification states that peaking would occur once a week with a priority given to Saturdays, Sundays, and Fridays, in that order, between the hours of 9 AM and 2 PM, as measured at the Spring Island Boater Access. In a January 30, 2007, memorandum to the Commission, the Bureau of Land Management stated that this modified 4(e) condition would diminish the ORV of summer whitewater boating and the ability to wade while fishing, but not unreasonably so. Oregon Fish & Wildlife and Cal Fish & Game provided an alternative to the Bureau of Land Management's preliminary 4(e) condition that would eliminate this once per week flow event, consistent with their section 10(j) recommendations. Upper Klamath Outfitters Association recommends PacifiCorp continue to operate the project in a peaking mode to provide flows of at least 1,500 cfs and consult with them to ensure both beneficial power production and public access to the river (timing, duration, and seasonal aspects of releases). They further recommend increasing whitewater boating opportunities during months with the highest demand (July, August, and September).

Oregon Fish & Wildlife, the Forest Service, the Hoopa Valley Tribe, and Cal Fish & Game also made flow recommendations that pertain to releases from Iron Gate dam, described in section 3.3.3.2.1, *Instream Flows*. There are slight variations between these recommendations but, in general, the minimum instream flows would range between 1,000 and 5,400 cfs, depending on the month of the year

[140]Flows would be provided unless there is a General Alert Status and would be measured at USGS gage no. 11510700, located downstream of the J.C. Boyle powerhouse.

and water year type. The Forest Service includes a separate recommendation to provide at least 1,000 cfs below Iron Gate dam to support boating-based angling.[141]

Oregon Fish & Wildlife, Oregon Parks & Rec and the Hoopa Valley Tribe recommended PacifiCorp continue to provide a flow phone and other outreach mediums to offer real-time flow projections and daily streamflow information. Posted information would include regularly scheduled project releases, geomorphic and natural spill events, hourly flows, and projected 24-hour flow information. The Bureau of Land Management specifies that PacifiCorp, within 1 year of license issuance, provide instantaneous 30-minute real time streamflow data in cfs via remote access that is readily available and accessible to the public.

Our Analysis

To analyze the effects of PacifiCorp's proposal and the recommendations of others, we focused on existing and potential recreational opportunities and attributes in the various reaches that could be created or affected by the flow measures. We also focused our analysis on the period of April 1 through October 31 because most water-based recreational activities take place during these months. We analyzed the various measures to evaluate how many days would be available in each of these months based on the hydrologic record (see section 3.3.2, *Water Resources*) for above average, average, and below average water years, which represent the majority of water years and is indicative of how alternative flow regimes would influence recreational opportunities. Our analysis took into account ramping rates and we discuss any reach-specific assumptions within the analysis of each reach. Although we analyze the measures relative to angling opportunities, it is important to note that the following analysis reflects an angler's ability to catch fish (e.g., wading, turbidity), as opposed to the abundance or size of fish that may be present. We note that any alternative that results in restoration of anadromous fish upstream of Iron Gate dam would also create enhanced angling opportunities within the constraints of applicable angling regulations (see section 3.3.3.2.5, *Anadromous Fish Restoration*).

Flow Measures, Link River Reach. In analyzing the flow measures for this reach we considered: (1) the reach receives substantial visitor use because of its proximity to Klamath Falls, (2) angling and locational playboating are popular activities at the reach, and (3) during the winter and spring, the typical existing flows in this reach are between 500 and 1,500 cfs. Based on these considerations we determined there would be occasional whitewater playboating opportunities provided by the spill events that would take place under any of the measures. For comparison, we looked at existing conditions and found suitable flows for whitewater boating (between 2,000 and 3,000 cfs) would occur about 3 and 12 days in April and May, respectively, during an average water year.

Angling is a more popular activity in the reach, so we based our analysis on the optimal range of angling flows (see section 3.3.6.1.2, *Project Recreational Resources*). This analysis shows that increased angling opportunities would be provided by low flows (figures 3-108, 3-109, and 3-110). All of the measures would provide some angling opportunities during the period, but during above average water years most of the opportunities from April through August would be eliminated with either the Oregon Fish & Wildlife recommendation or decommissioning East Side and West Side developments. Currently, discharge from the East Side development enters the bypassed reach about 3,700 feet downstream from Link River dam. Discharge from West Side development enters the bypassed reach about 5,300 feet downstream of the dam, near the end of the riverine section of Link River.

[141]The Forest Service recommendation states that when flows are not available, Iron Gate would be operated in a run-of-river mode.

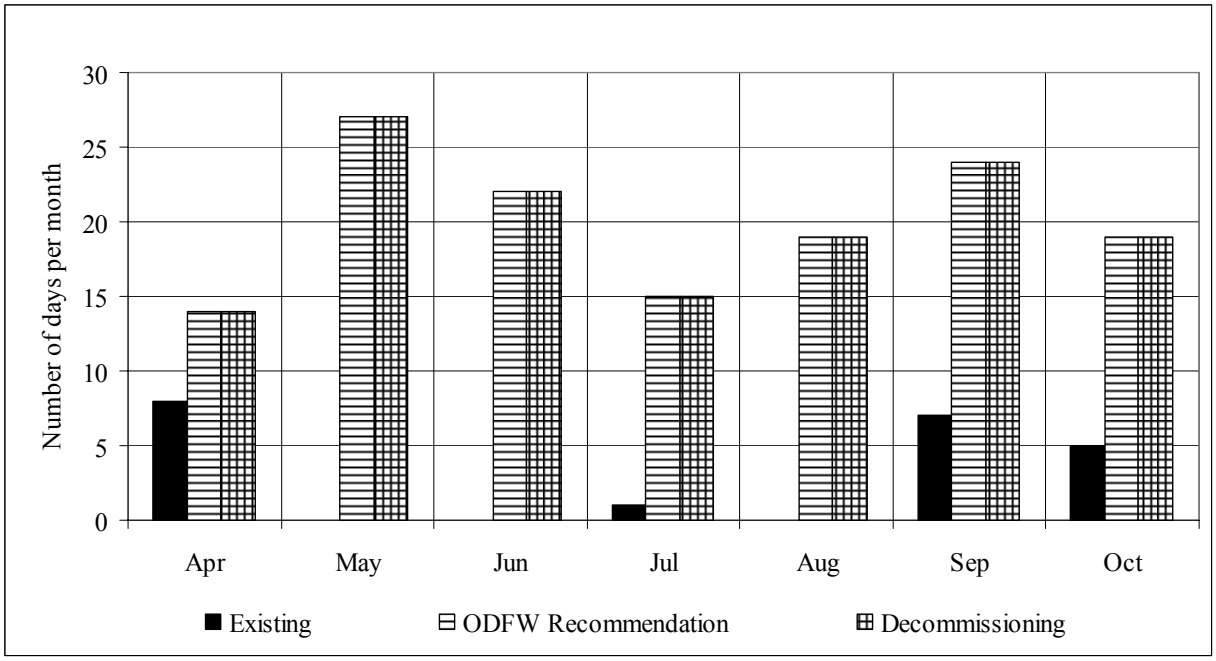

Figure 3-108. Below average water year type, Link River bypassed reach optimal angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

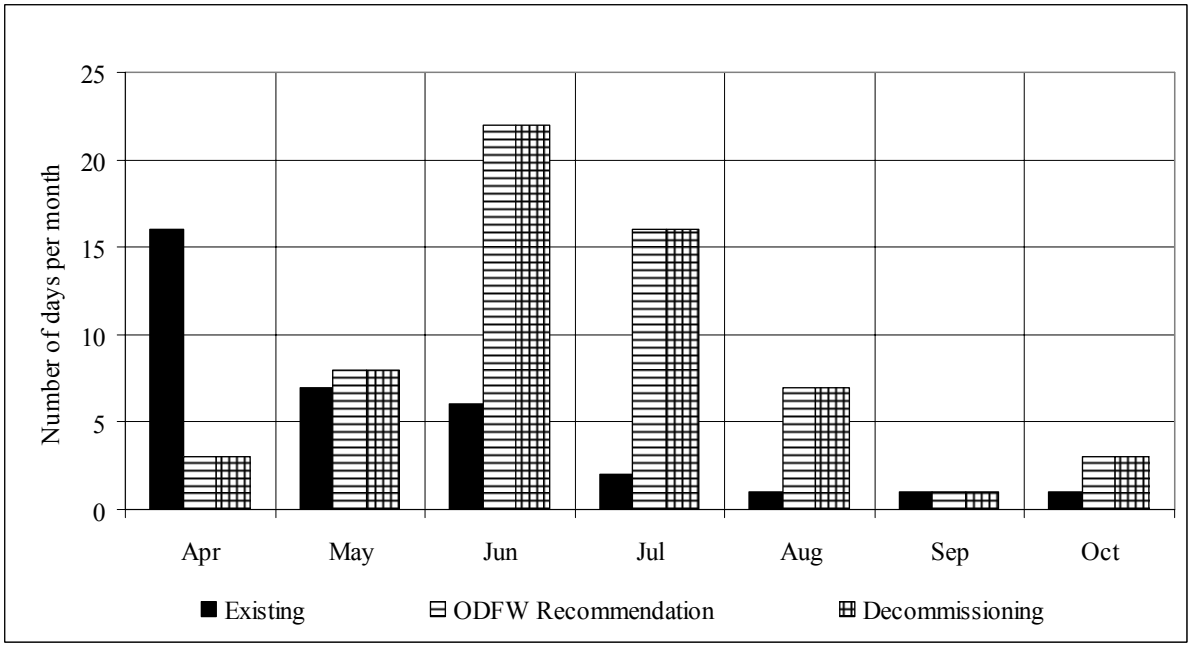

Figure 3-109. Average water year type, Link River bypassed reach optimal angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

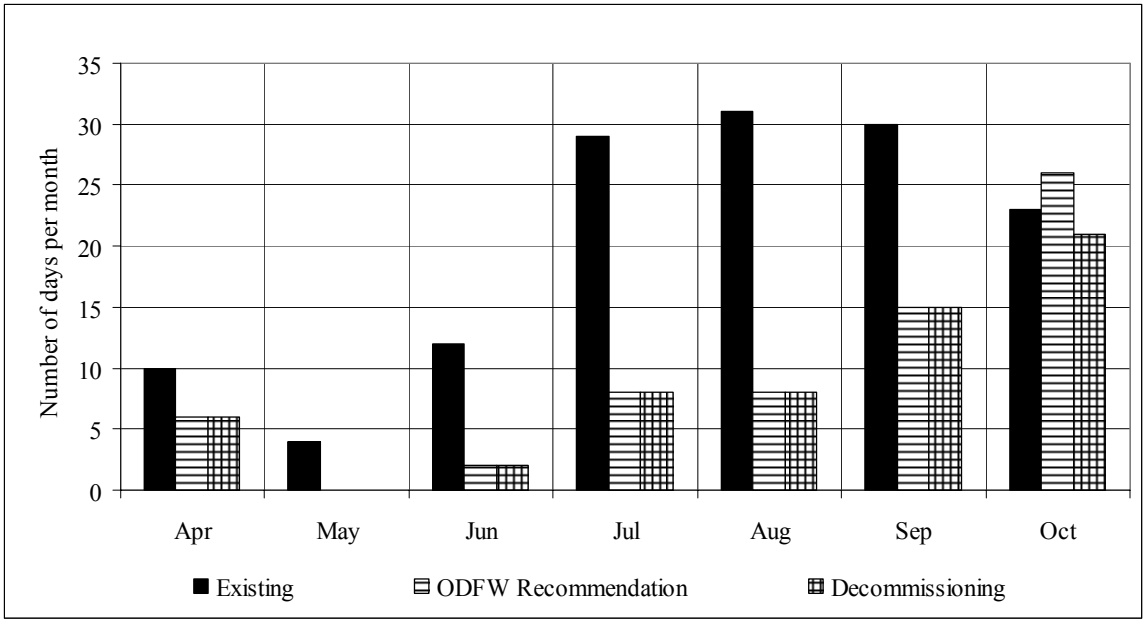

Figure 3-110. Above average water year type, Link River bypassed reach optimal angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

Flow Measures, Keno Reach. The agencies flow recommendations would result in run-of-river operation, which would be equivalent to existing conditions. Consequently, the agency recommendations and decommissioning would not cause an appreciable change in the angling and boating opportunities in this reach.

Flow Measures, J.C. Boyle Bypassed Reach. In analyzing the flow measures for this reach, we considered: (1) this reach is one of the two most important reaches in the project for angling, (2) this reach is suited for private whitewater boating because of the length of the run and access,[142] and (3) spill events rarely occur, especially from Memorial Day to Labor Day (see table 3-19). Based on these considerations, we analyzed the effects of flow-related measures relative to the optimum and acceptable ranges of flows for angling and acceptable range of flows for technical kayaking. PacifiCorp currently releases a minimum flow of 100 cfs to the bypassed reach and proposes to release an additional 100 cfs from either the dam or the powerhouse. Our analysis makes the assumption that PacifiCorp would release this additional 100 cfs at the J.C. Boyle dam. Figures 3-111, 3-112, and 3-113 show that almost all angling opportunities in the optimal range of flows would be eliminated under the Oregon Fish & Wildlife and Bureau of Land Management flow measures and dam removal. Under the PacifiCorp proposal, the flow in the majority of the bypassed reach would be slightly above the optimal range, due to minimum flow release of 200 cfs and the addition of about 225 cfs from the springs in the upper sections of the bypassed reach. However, the total number of days available within the acceptable range for angling (figures 3-114, 3-115, and 3-116) would be about the same for all of the measures and dam removal. This comparison reflects the sensitivity of the analysis to the selected range of flows. We consider it most appropriate to consider the data set for the acceptable, rather than optimal, range of angling flows recognizing that anglers would still probably attempt to fish even if optimum flow conditions did not exist because of the quality of the fishery. Regarding kayaking opportunities, in average and above average water years (figures 3-117, 3-118, and 3-119), PacifiCorp's and the Bureau of Land Management's measures would provide only occasional opportunities during April, May, and June and essentially no opportunities in July through October. However, there would be frequent opportunities

[142] We assume most private boating use would be in the form of kayaking as opposed to rafting.

for kayaking in July through October under the Oregon Fish & Wildlife measure and dam removal in all three water year types.

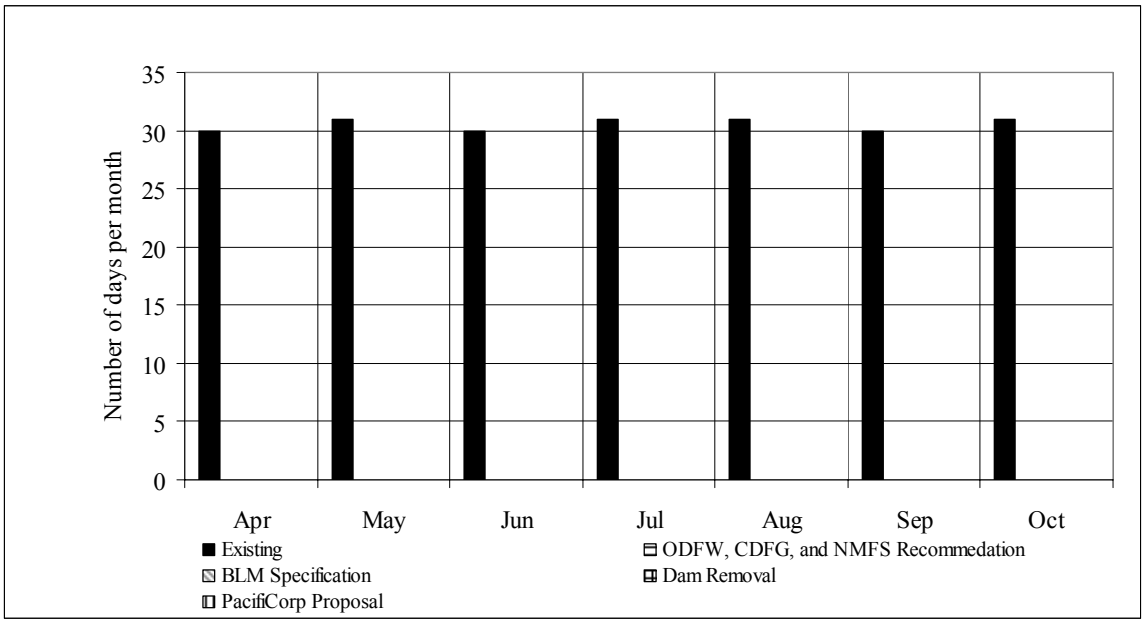

Figure 3-111. Below average water year type, J.C. Boyle bypassed reach optimal range of flows for angling (flows between 300 and 400 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

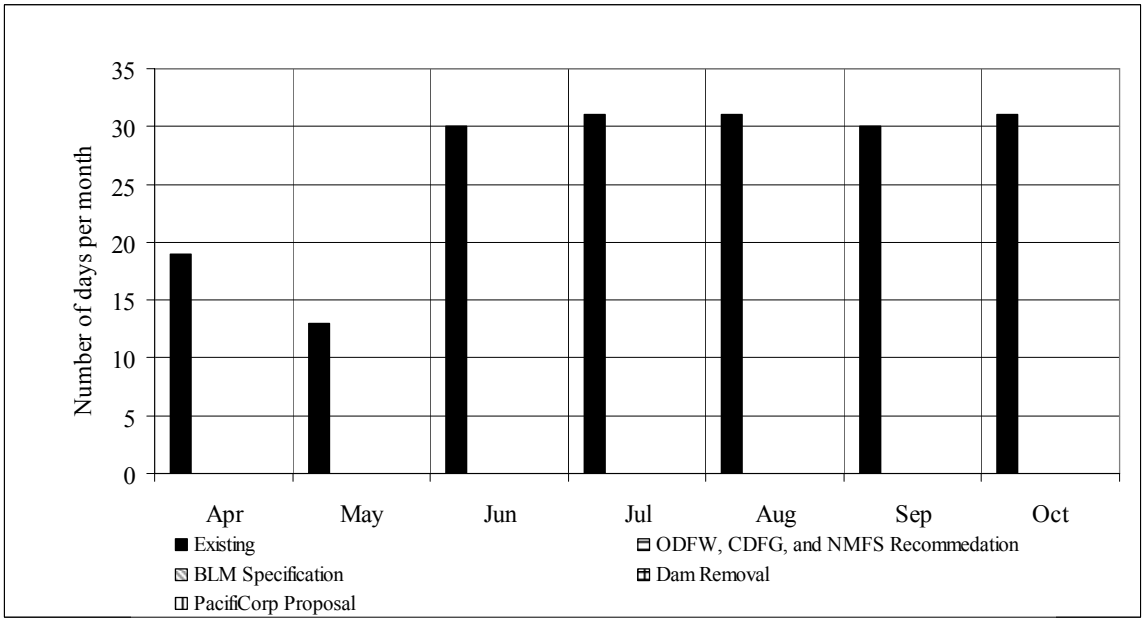

Figure 3-112. Average water year type, J.C. Boyle bypassed reach, optimal range of flows for angling (flows between 300 and 400 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

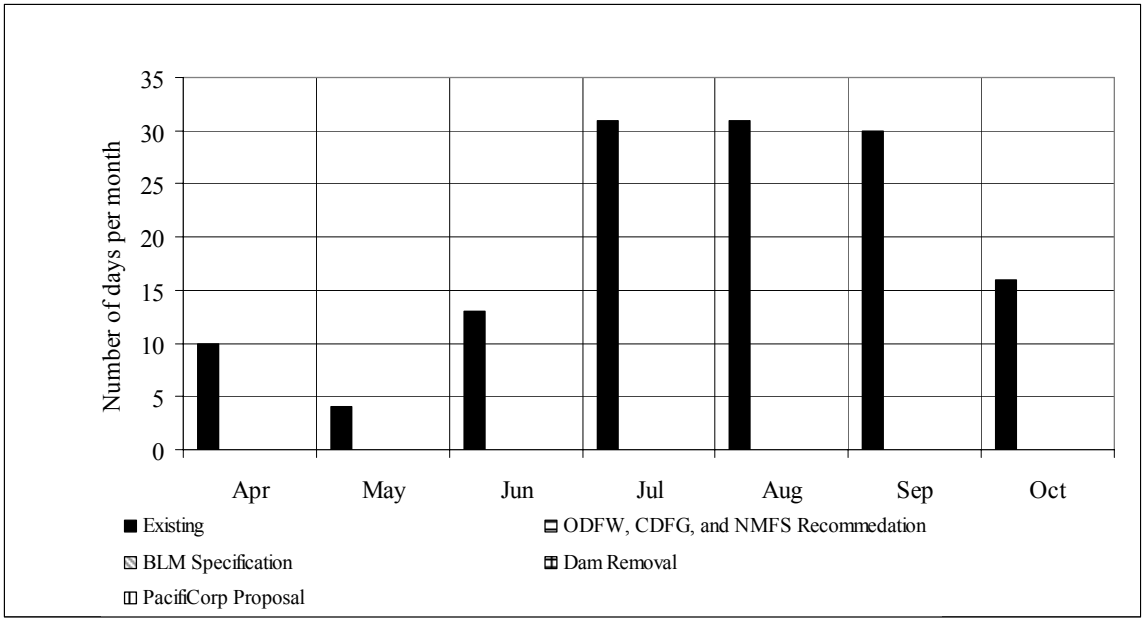

Figure 3-113. Above average water year type, J.C. Boyle bypassed reach optimal range of flows for angling (flows between 300 and 400 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

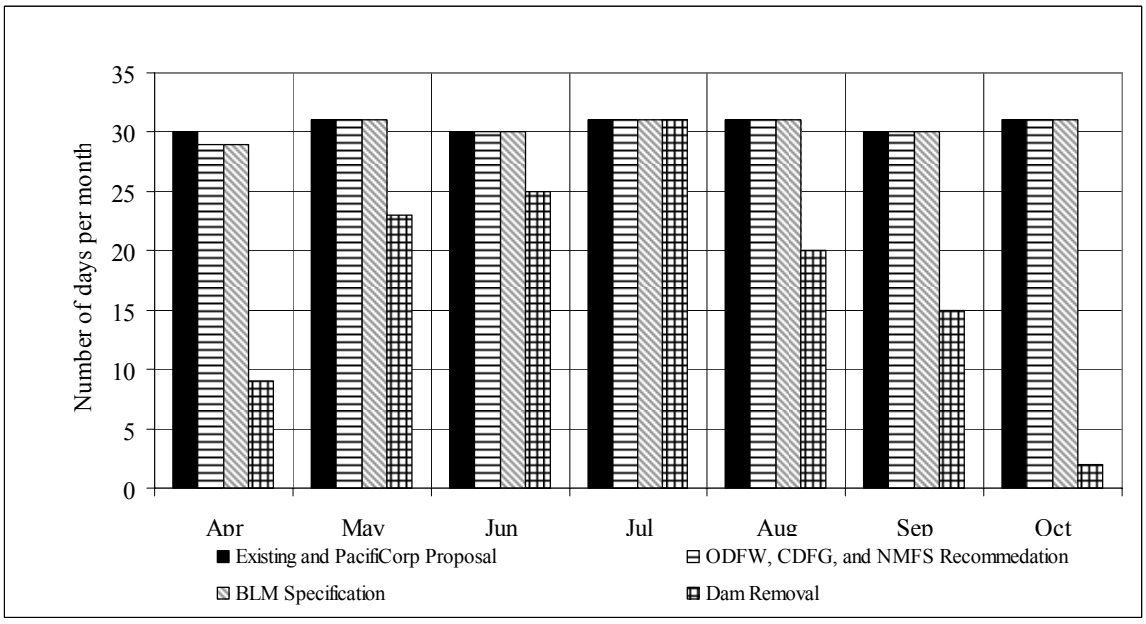

Figure 3-114. Below average water year type, J.C. Boyle bypassed reach acceptable range of flows for angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

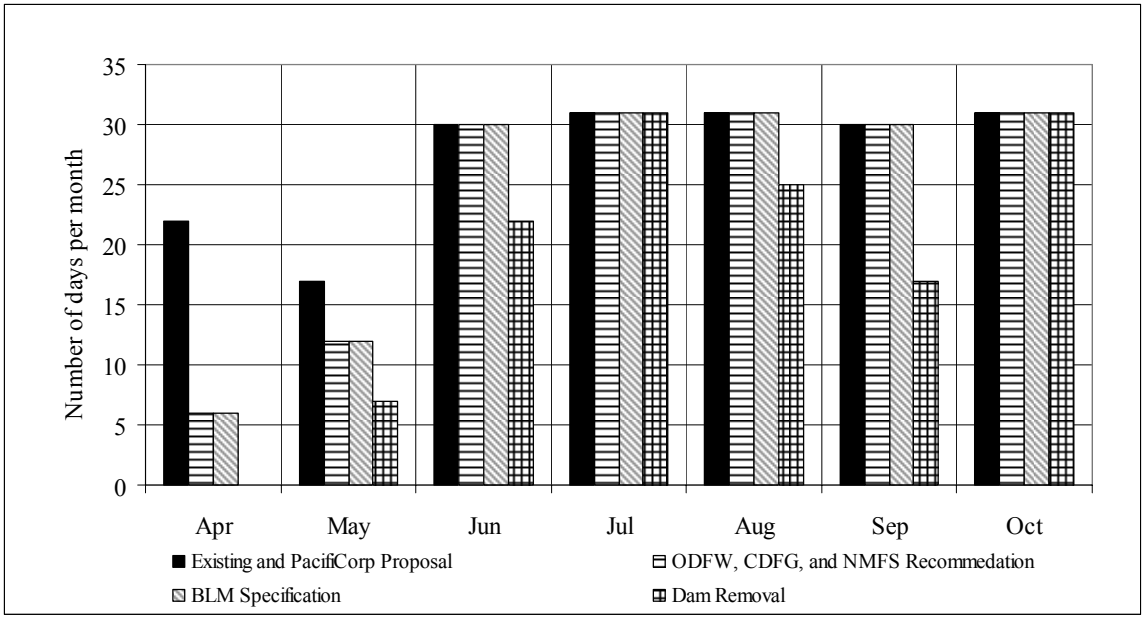

Figure 3-115. Average water year type, J.C. Boyle bypassed reach acceptable range of flows for angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

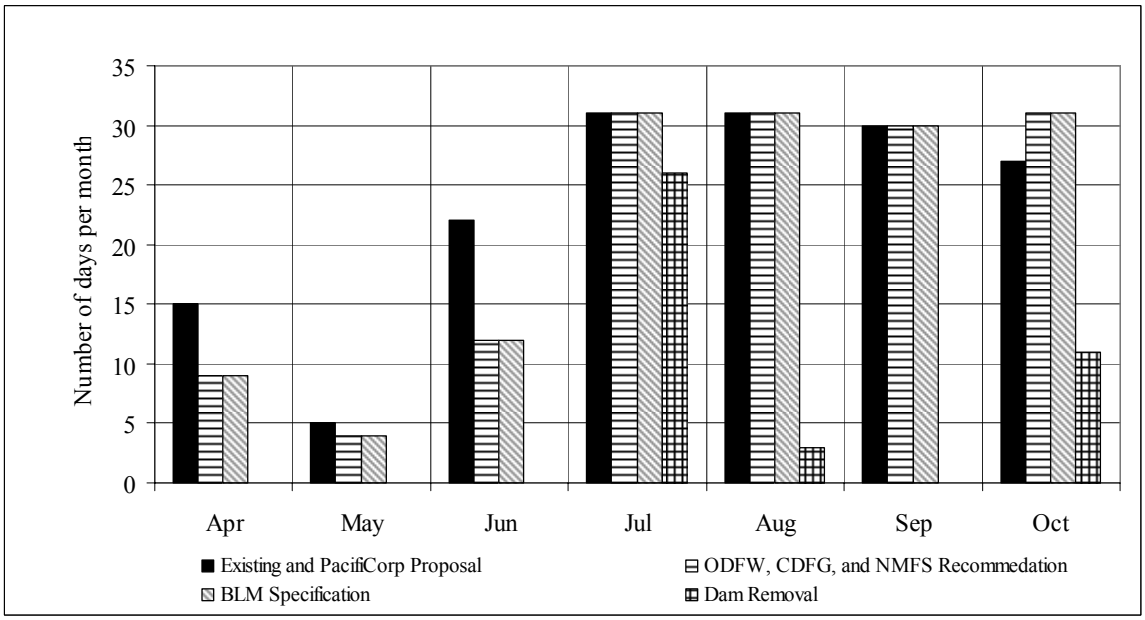

Figure 3-116. Above average water year type, J.C. Boyle bypassed reach acceptable range of flows for angling (flows between 200 and 1,000 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

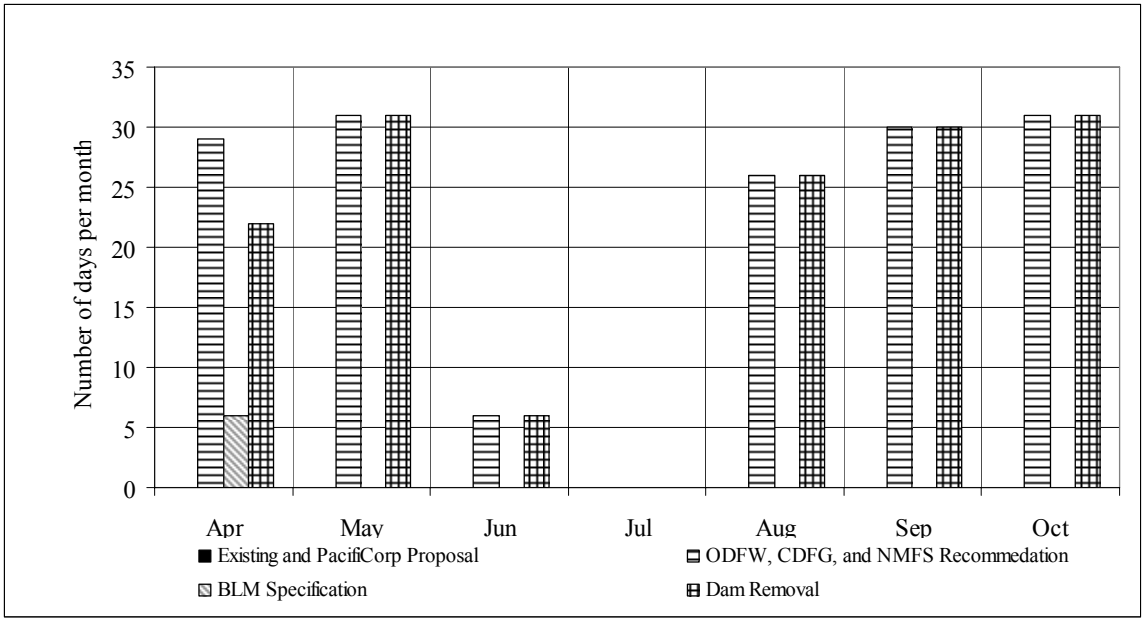

Figure 3-117. Below average water year type, J.C. Boyle bypassed reach acceptable range of flows for technical kayaking (flows between 800 and 1,300 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

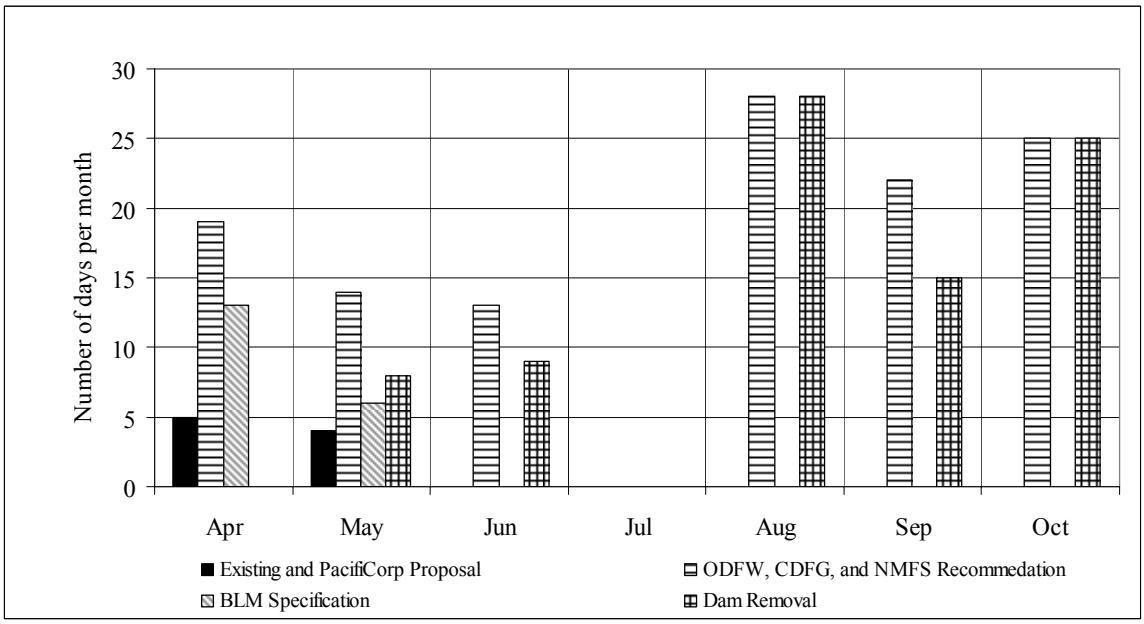

Figure 3-118. Average water year type, J.C. Boyle bypassed reach acceptable range of flows for technical kayaking (flows between 800 and 1,300 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

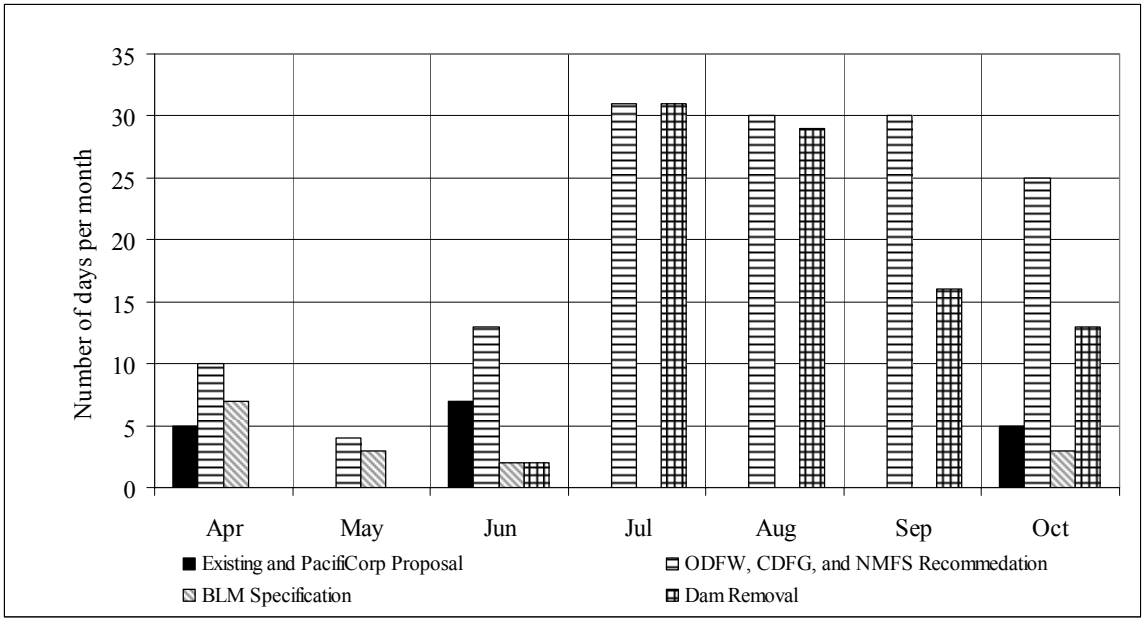

Figure 3-119. Above average water year type, J.C. Boyle bypassed reach acceptable range of flows for technical kayaking (flows between 800 and 1,300 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

Flow Measures, J.C. Boyle Peaking Reach. In analyzing the flow measures for this reach, we considered these factors: (1) this reach is designated a Wild and Scenic River with ORVs of quality whitewater boating and quality rainbow trout fishery; (2) this reach is best suited for commercial whitewater boating use because of its technical difficulty and complex access; (3) there is a critical transition point at about 1,500 cfs below which whitewater rafting experiences are notably less desirable and present safety concerns; (4) similarly, safety becomes a concern at flows over 3,500 cfs; (5) 5,250 of the estimated 12,647 annual recreation days in this reach are attributed to the commercial boating use; (6) only incidental private boating occurs in the reach; and (7) although kayaking is feasible in this reach, providing kayaking opportunities at this reach is a low priority based on documented use levels that show relatively infrequent private boating use (likely caused by the lengthy shuttle and technical difficulty of the estimated 52 almost continuous rapids). Based on these considerations, we analyze the effects relative to a flow range of 1,500 to 3,500 cfs to provide standard commercial rafting opportunities. Our analysis assumes a 4-hour launch window would provide sufficient time for boaters to complete the run before the flow ramps down. This range of flows and launch window reflects the importance of boater safety and ORVs for this reach. The lower end of the flow range is also consistent with the Bureau of Land Management's flow measure. To analyze angling opportunities, we evaluated the measures relative to both the acceptable and optimum ranges of flows for this activity.

The Bureau of Land Management provides its analysis of the number of boatable days that would be available if the project were operated according to the agency's specification. This analysis is based on their Flow Management Scenario (FMS) model that estimates the number of days when flows over 1,500 cfs would occur. The number of predicted boatable days that would occur under the Bureau of Land Management's specification by month and weekday vs. weekend for three water year types is shown in table 3-100.

Table 3-100. Number of days with flows over 1,500 cfs in the peaking reach under the Bureau of Land Management's modified 4(e) conditions, as modeled by the Bureau of Land Management flow management scenario. (Source: Bureau of Land Management, 2006b)

	May - October		July and August	
Water Year Type	**Number of Boatable Days**	**Number of Boatable Weekend Days[a]**	**Number of Boatable Days**	**Number of Boatable Weekend Days[a]**
Dry (1994)	6	6	0	0
Average (2000)	102	64	18	17
Wet (1998)	120	69	22	20

[a] Friday, Saturday, and Sunday.

To analyze the Bureau of Land Management specification, we conducted a similar analysis, but used the monthly median flow values from USGS gage no. 11510700 at the Klamath River below J.C. Boyle powerhouse. The median flow is the most common flow that occurs and, at this gage, the mean and median monthly flow values are similar for the months of July through October. Using the monthly median flow removes some of the anomalies which could skew the results of the FMS model (which is based on flow during a particular year). Our analysis uses the Bureau of Land Management's minimum flow, ramping rates and other specifications, but also uses the full extent of water storage within J.C. Boyle reservoir down to an elevation of 3,782 feet,[143] slightly above the crown of the intake structure. In addition, our analysis assumes that PacifiCorp would generate at less than full capacity on some days to enhance the number of days with flows in excess of 1,500 cfs; however, when possible, full one unit (1,300 cfs +/-) generation would occur on Saturday and Sunday. The use of the entire active storage of the reservoir and the partial generation assumptions would maximize the number of days in the peaking reach with flows above 1,500 cfs. Flows in the peaking reach can reach 1,500 cfs with about 800 cfs released from the powerhouse, due to the bypassed reach minimum flows specified by the Bureau of Land Management, and groundwater accretion from the bypassed reach. Figure 3-120 shows the generation flow, peaking reach flow, and water surface elevation at J.C. Boyle reservoir which would result during idealized August operations when PacifiCorp would provide at least 1,500 cfs to the peaking reach. Table 3-101 shows the number of boatable days per month and the number of boatable weekend days (Friday/Saturday/Sunday) which result from our analysis.

[143] Current normal minimum operating level of J.C.Boyle reservoir is 3,788 feet.

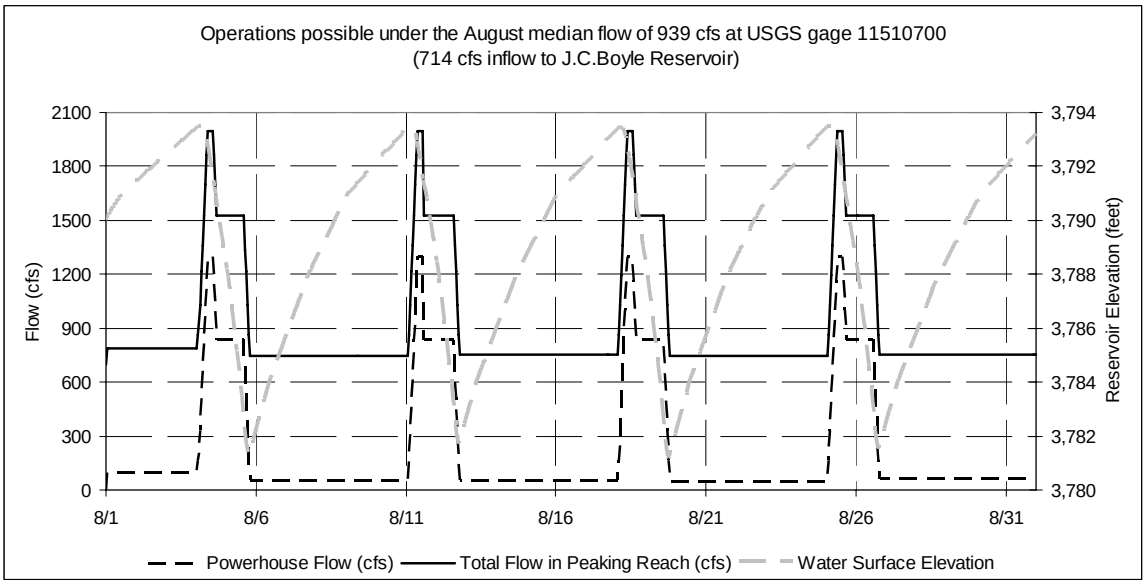

Figure 3-120. Modeled flow and reservoir elevations during August based on the median monthly flow under the Bureau of Land Management's modified 4(e) conditions. (Source: PacifiCorp, 2005f; USGS, 2005 as modified by staff)

Table 3-101. Number of days per month between 1,500 and 3,500 cfs in the peaking reach per month under the Bureau of Land Management's modified 4(e) conditions, based on the median monthly flows. (Source: PacifiCorp, 2005f; USGS, 2005 as modified by staff)

Month	Number of boatable days	Number of boatable weekend days[a] per month
May	18	13
June	9	9
July	0	0
August	9	9
September	13	13
October	22	13
Total Days	70	57

[a] Friday, Saturday, and Sunday.

Our analysis, using the median monthly flows, predicts fewer boatable days would occur in the May – October period and during the key recreation months of July and August than what is predicted using the Bureau of Land Management's FMS model (table 3-100). Operational constraints that are included in our model but not the FMS model contribute to the difference in the number of predicted boatable days that would occur under the Bureau of Land Management 4(e) condition. We also note that the FMS model assumes that if flow could be released from J.C. Boyle reservoir storage to accommodate recreational boating flows from Monday through Thursday, such releases would contribute to the total number of boatable days. Such releases would not be consistent with the modified 4(e) condition. Non-weekend releases suitable for boating could also occur when inflow to J.C. Boyle reservoir exceeds the maximum turbine capacity of the powerhouse. The one additional boatable day that would occur during the week in an average year and two additional boatable days that would occur during the week in a wet year, could be due to either factor.

We also analyze the effects of Bureau of Land Management's specification on reservoir levels during the month of August, which is a peak use time for boating and other flatwater recreational activities on J.C. Boyle reservoir. In general, the modified 4(e) condition would cause the reservoir to have a weekly fluctuation pattern as compared to the daily 1 to 2 feet fluctuation that currently exists. Operating under the Bureau of Land Management specified flows to produce the number of boatable days provided in table 3-101, the reservoir would lower as much as 12 feet over a two day period in response to the whitewater events and then would slowly refill during the week. This operation would be noticeably different than what currently exists and could affect recreational use at the reservoir in terms of boating access and aesthetic value. We also note that the 12-foot drawdown that would occur under the Bureau's flow specification is much different than the existing 5.5 feet reservoir operating range. Resource balancing decisions could be made to reduce the extreme reservoir fluctuations and substantial reduction in generation that would be necessary to extend boating releases to two days during the drier times of the recreational season. However, minimizing reservoir fluctuations and generation curtailment would generally result in recreation releases that are no longer than one day.

We also analyze the measures with respect to three water year types. During above average, average, and below average water years, our analysis indicates standard whitewater boating opportunities would be largely eliminated between April and October under the Cal Fish & Game and Oregon Fish & Wildlife measures and dam removal scenarios that would each result in run-of-river operation (figures 3-121, 3-122, and 3-123). The Bureau of Land Management's measure would provide at least 1 day per week of whitewater boating opportunity between May and October, except during July in below average water year types. However, this would be substantially lower than PacifiCorp's proposed operation and the Upper Klamath Outfitters Association's recommendation, which is similar to existing conditions. We note that PacifiCorp's proposed operation would provide slightly more boatable days in all types of water years than currently exist, because of its proposal to normally limit peaking operations to one unit.

Our analysis offers compelling evidence that continued peaking operations, as proposed by PacifiCorp, would provide enhanced whitewater boating opportunities in the peaking reach. The proposed operational mode would support the ORV of whitewater boating for this Wild and Scenic River. PacifiCorp's proposed operational mode would provide more boating opportunities compared to all other specified and recommended measures. In general, it would provide between 18 and 30 days per month from June through October in all types of water years and from July through October during above average water years. The Bureau of Land Management measure would provide between 2 and 15 boatable days per month between June and October, depending on the month and water year type. However, in an average year, when the number of boatable days provided under the Bureau of Land Management scenario in April and May would be comparable to all of the other specifications and recommendations, there would be no boatable days provided in July and fewer than 10 boatable days per month in June and in August through October. This amounts to less than one-third of the boatable days that would be provided by PacifiCorp's proposed flow measure. Under the Oregon Fish & Wildlife and Cal Fish & Game measures, dam removal scenario, or the Bureau of Land Management modified 4(e) condition, the opportunity for whitewater boating, an ORV for this Wild and Scenic River, would be severely diminished.

Angling is another ORV of this designated Wild and Scenic River and we analyzed the number of days that would be available under the various measures. Our analysis assumed angling opportunities would be provided even on days when peaking flows occur because there would likely be at least several hours with low flows in both the morning and evening hours, which are the preferred times of day to fish, at both the upper and lower ends of the reach where there is the most angling access. Our analysis (figures 3-124 through 3-129) shows that all of the measures would provide almost daily angling opportunities within an acceptable range of flows between July and October.

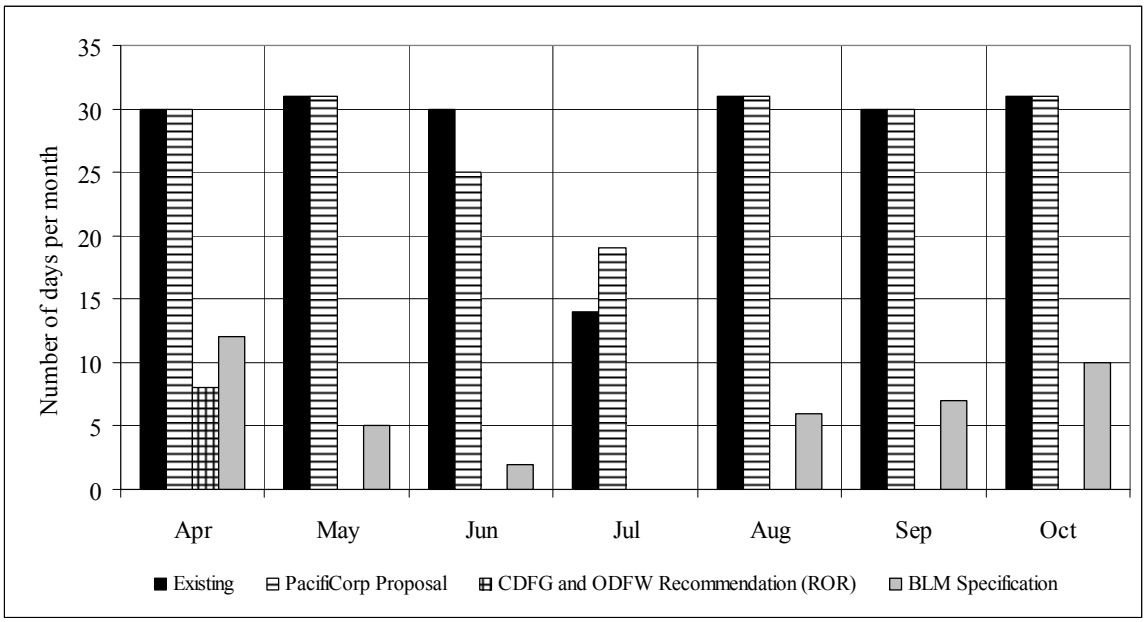

Figure 3-121. Below average water year type, J.C. Boyle peaking reach, acceptable range for commercial rafting (flows between 1,500 and 3,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

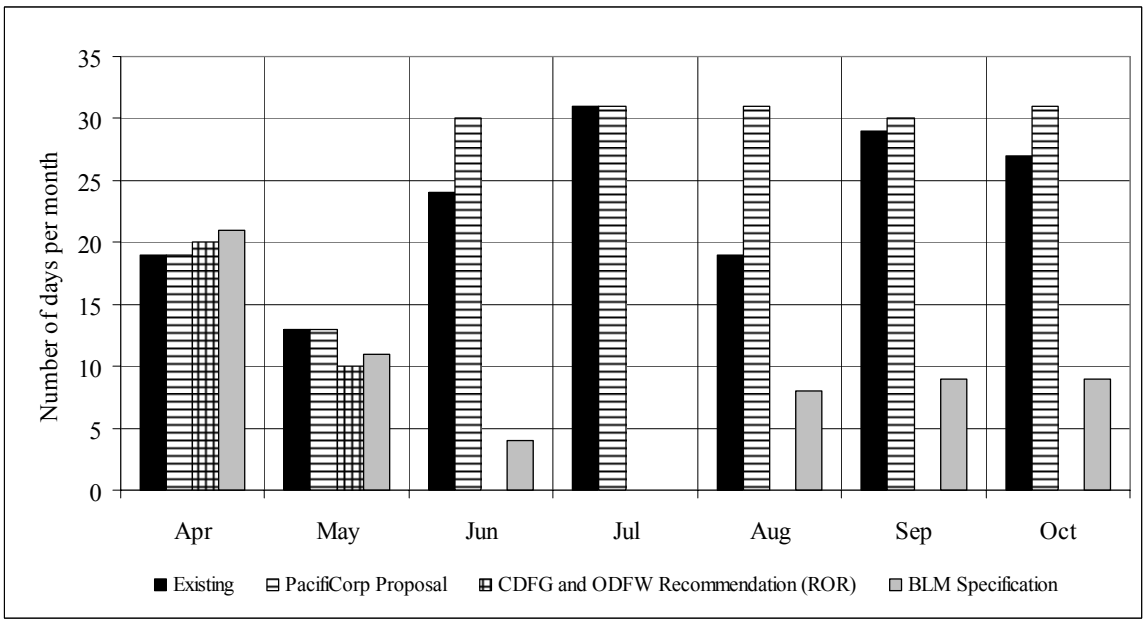

Figure 3-122. Average water year type, J.C. Boyle peaking reach, acceptable range for commercial rafting (flows between 1,500 and 3,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

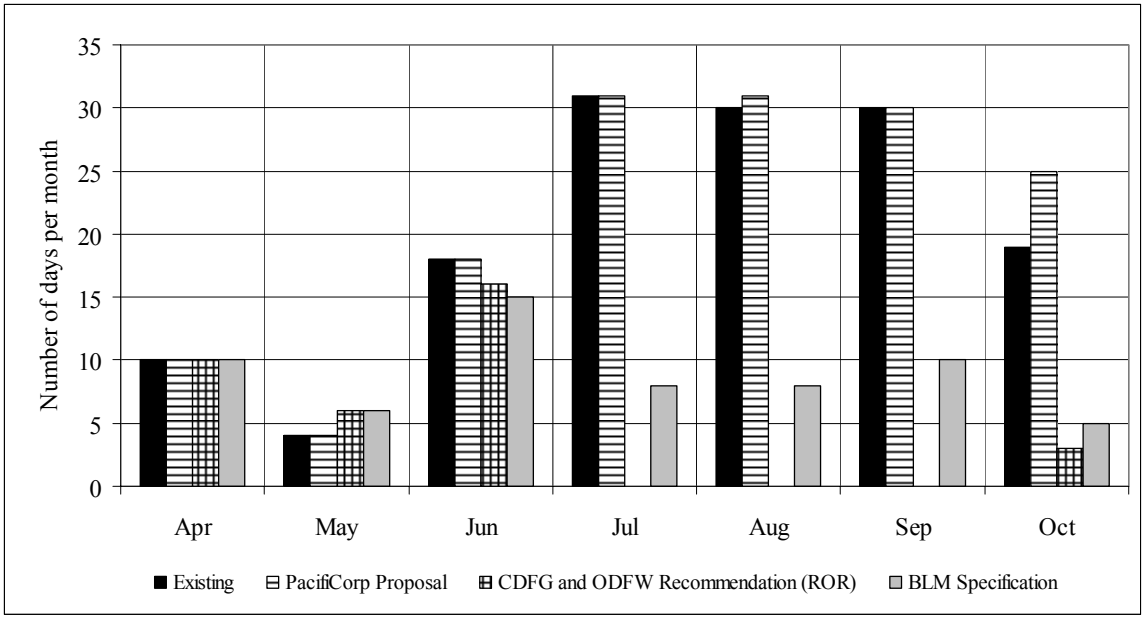

Figure 3-123. Above average water year type, J.C. Boyle peaking reach acceptable range for commercial rafting (flows between 1,500 and 3,500 cfs). (Source: PacifiCorp, 2005f, USGS, 2005)

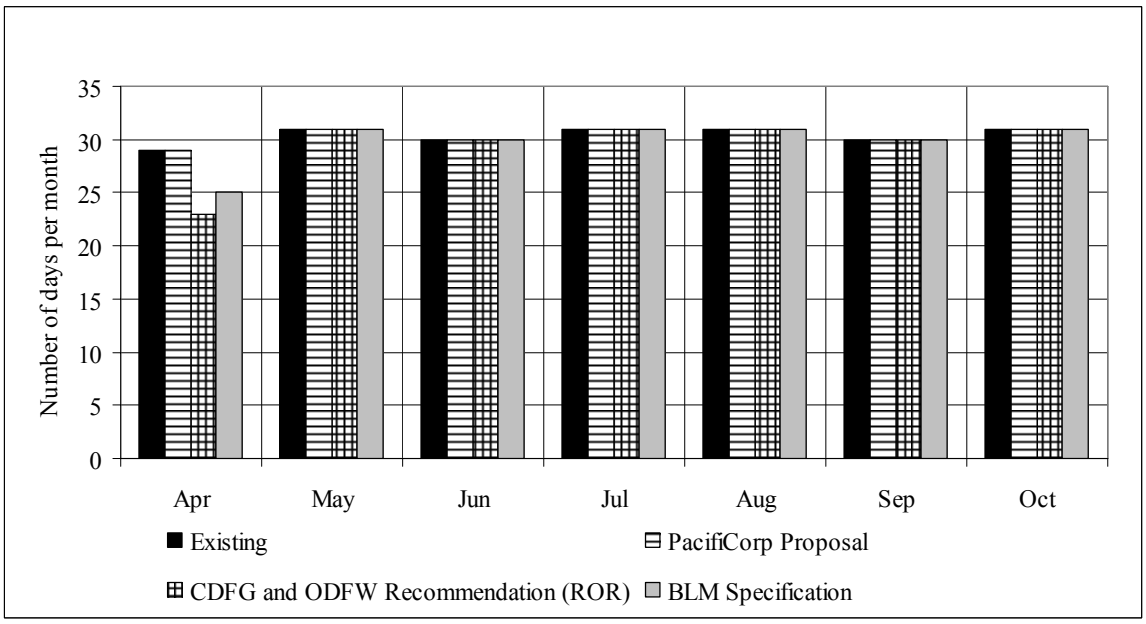

Figure 3-124. Below average water year type, J.C. Boyle peaking reach, acceptable range of flows for angling (flows between 200 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

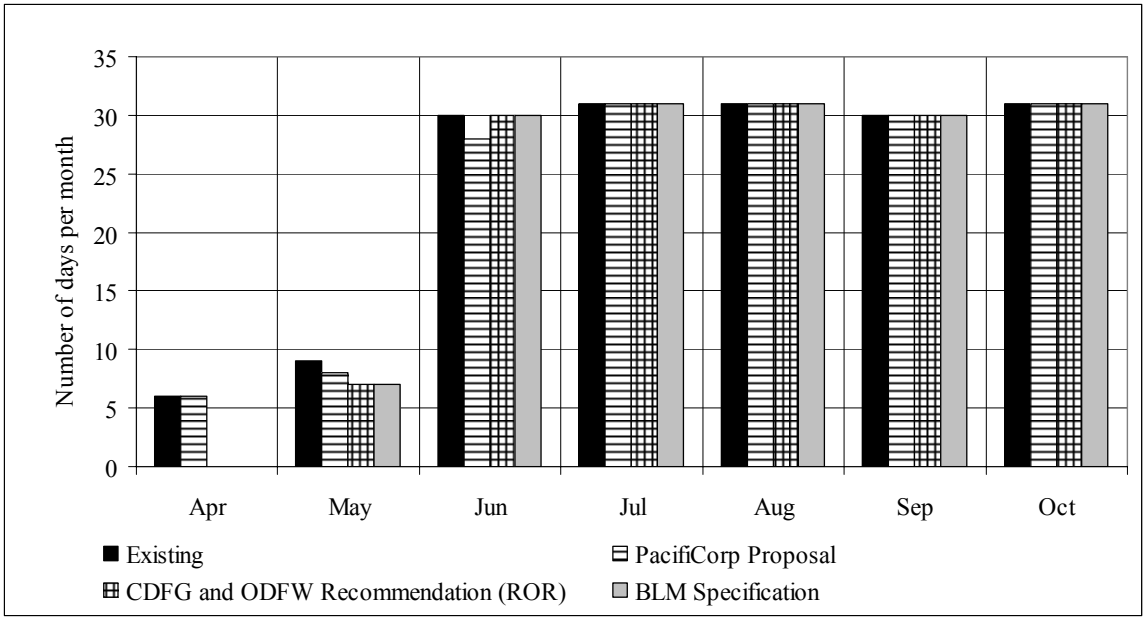

Figure 3-125. Average water year type, J.C. Boyle peaking reach, acceptable range of flows for angling (flows between 200 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

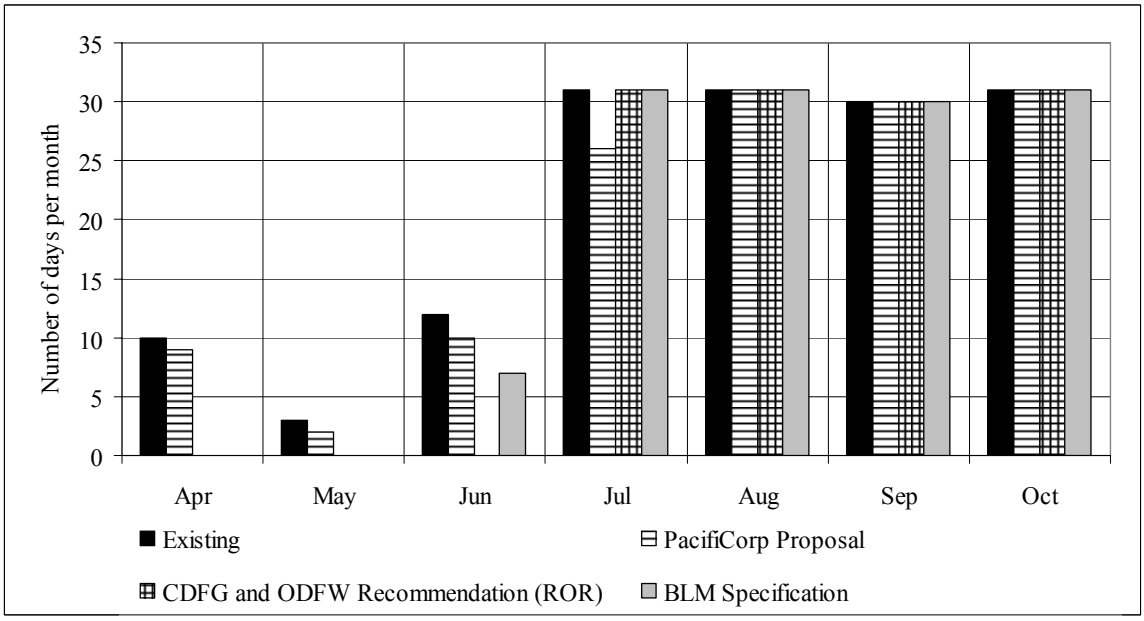

Figure 3-126. Above average water year type, J.C. Boyle peaking reach, acceptable range of flows for angling (flows between 200 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

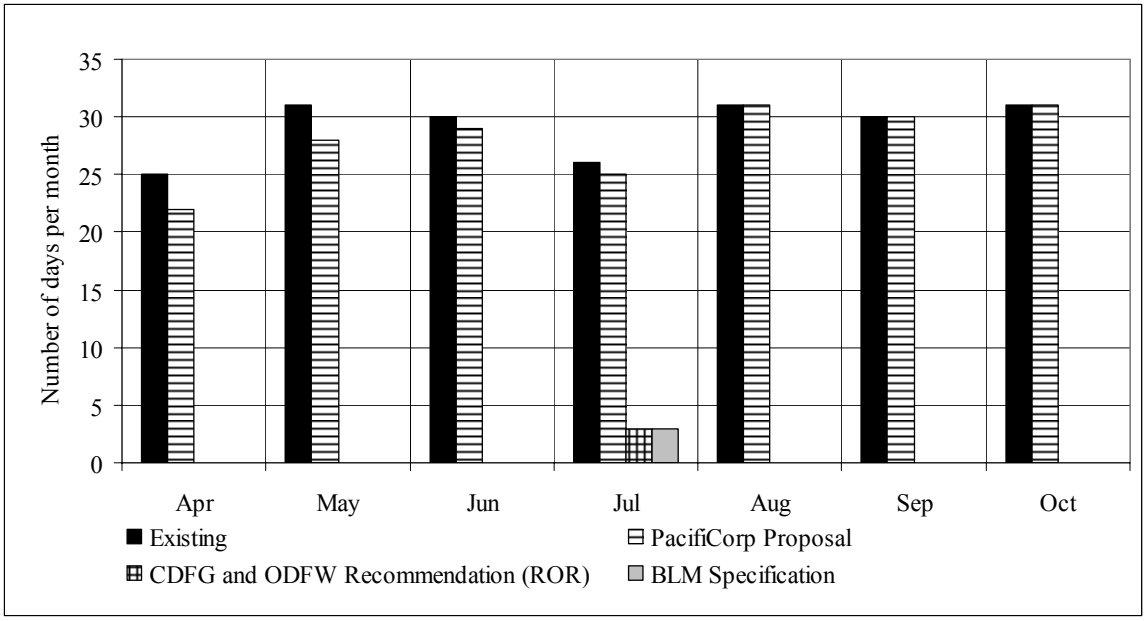

Figure 3-127. Below average water year type, J.C. Boyle peaking reach, optimal range of flows for angling (flows between 300 and 500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

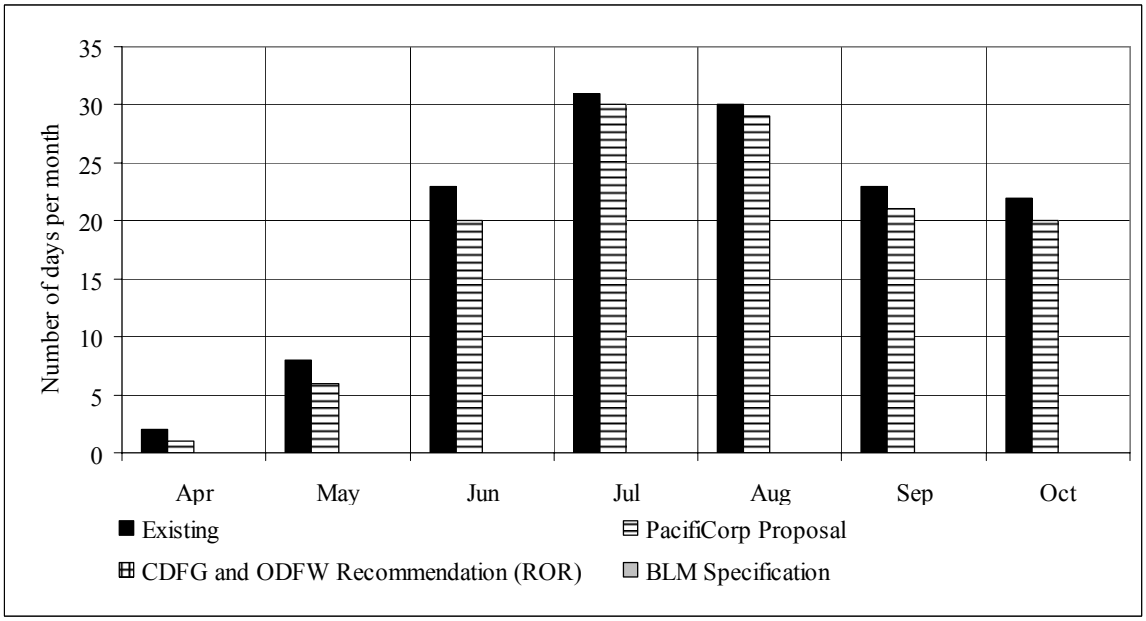

Figure 3-128. Average water year type, J.C. Boyle peaking reach, optimal range of flows for angling (flows between 300 and 500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

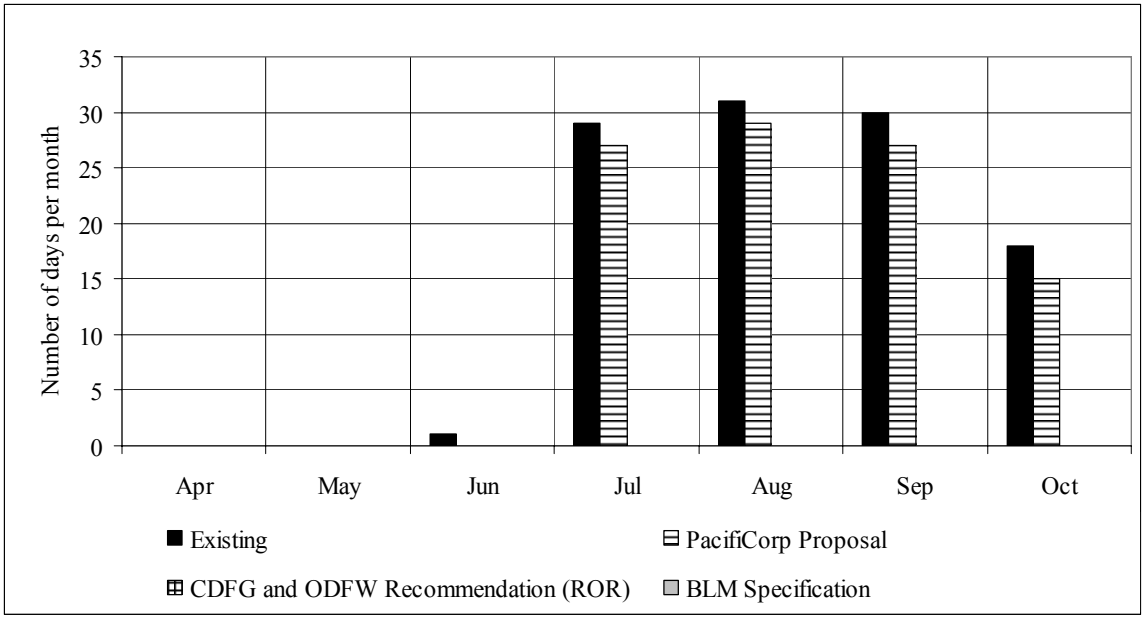

Figure 3-129. Above average water year type, J.C. Boyle peaking reach, optimal range of flows for angling (flows between 300 and 500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

In June, during above average water years, when high flows limit angling opportunities, PacifiCorp's proposed operations and the Bureau of Land Management specification would provide acceptable flows on at least 7 days during the month, whereas the Cal Fish & Game and Oregon Fish & Wildlife alternative measures would eliminate angling opportunities during the month using our assessment criteria. Within the optimum range of angling flows, there would be almost daily optimum flows provided from July through August and most of September in above average, average, and below average water year types under PacifiCorp's and Upper Klamath Outfitters Association measures. However, there would be no flows within the optimum angling range under the Oregon Fish & Wildlife or Cal Fish & Game measures between April and October in above average, average, and below average water years.

Recognizing that both angling and whitewater boating use contribute to this river's designation as a Wild and Scenic River, we consider the combined effects on both of these attributes. There would be comparable number of days with angling opportunities provided within the acceptable, but not optimal, range of angling flows under existing conditions, PacifiCorp's proposed operation, and Cal Fish & Game and Oregon Fish &Wildlife's flow measures. In stark contrast, as described above, the alternatives have drastically different effects on whitewater boating, ranging from providing optimal boating opportunities throughout much of the recreational season to opportunities being largely eliminated. Consequently, PacifiCorp's proposed operation or Upper Klamath Outfitters Association's flow measures would continue to provide whitewater boating opportunities while providing angling opportunities that would not be materially different from what the other alternatives would provide. The Bureau of Land Management, in its Preliminary Section 7(a) Wild and Scenic Rivers Act Determination and Report (Bureau of Land Management, 2007), reached a similar conclusion that the Staff Alternative, which includes PacifiCorp's proposed operation, would maintain or enhance the ORVs of recreation, scenery, fish, and wildlife. The Forest Service provided a Section 7(a) Wild and Scenic Rivers Act Preliminary Determination Report for the portion of the river located in California (Forest Service, 2006) and that concludes none of the action alternatives presented in the draft EIS would unreasonably diminish the scenic, recreational, fish, or wildlife values in the area upon its designation as a component of the National Wild and Scenic Rivers System.

Flow Measures, Copco No. 2 Bypassed Reach. In analyzing the flow measures for this reach we considered: (1) this reach is suited for private whitewater boating because of the length of the run and access,[144] and (2) the lack of publicly accessible roads and trails likely limit the amount of recreational use in this reach. Based on these considerations we analyzed the effects of the measures relative to the acceptable range for standard whitewater boating and angling. The agency recommendation and dam removal scenario would enhance whitewater boating opportunities in this reach by providing about 15 to 30 days a month with boatable flows from June through October (figures 3-130, 3-131, and 3-132). In comparison, PacifiCorp's proposed operation would provide less than 10 days per month and these would occur primarily in April and May and only in average and above average water years. Very few days with angling opportunities within an acceptable range of flows would be occur under any of the agency-recommended flow-related measures or the dam removal scenario (figures 3-133, 3-134, and 3-135).

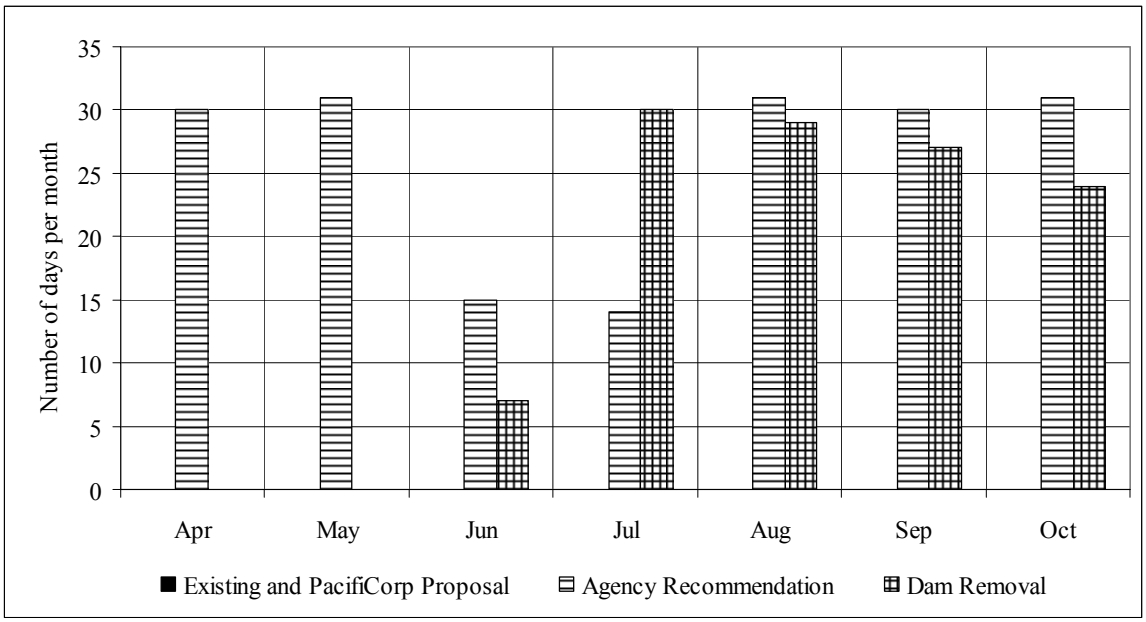

Figure 3-130. Below average water year type, Copco No. 2 bypassed reach acceptable range of flows for standard whitewater boating (flows between 600 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

[144]We assume most private boating use would be from kayaking as opposed to rafting.

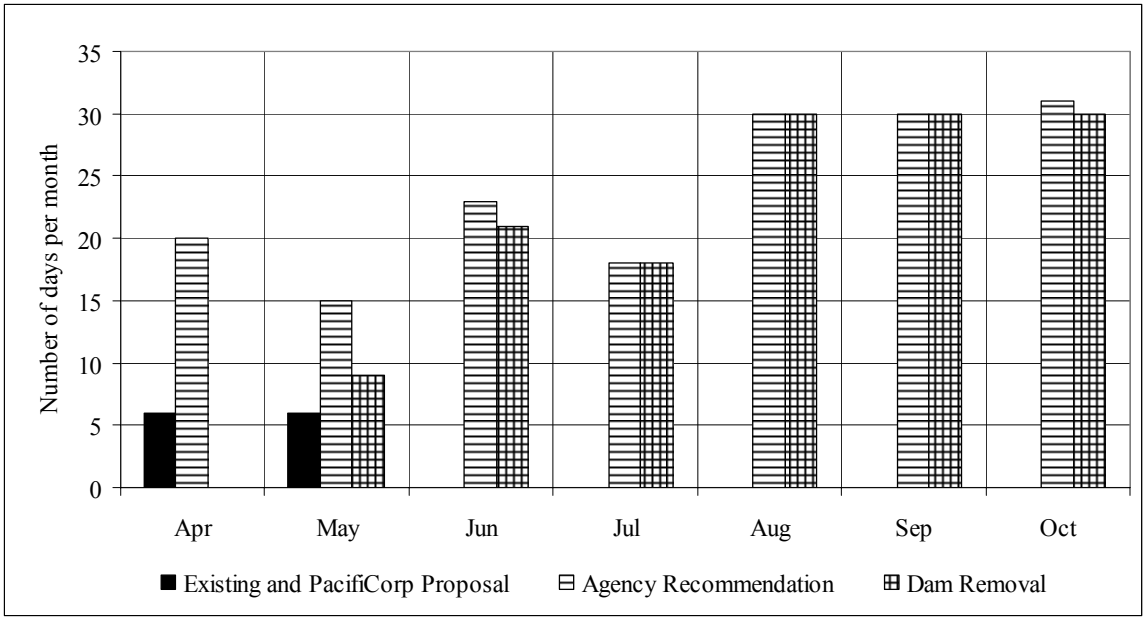

Figure 3-131. Average water year type, Copco No. 2 bypassed reach acceptable range of flows for standard whitewater boating (flows between 600 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

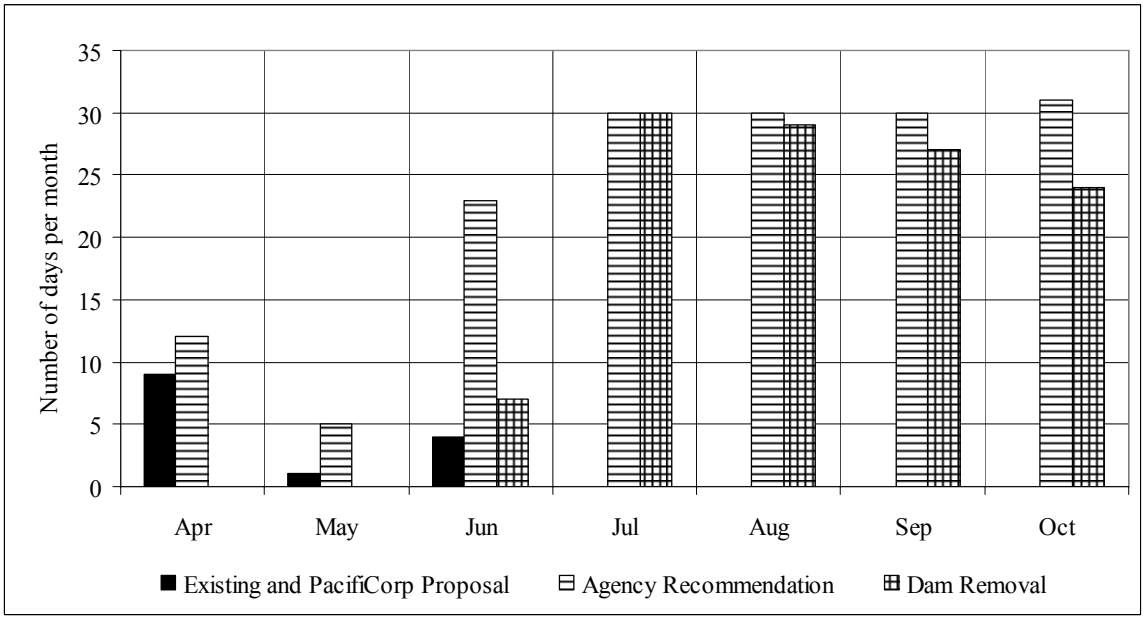

Figure 3-132. Above average water year type, Copco No. 2 bypassed reach acceptable range of flows for standard whitewater boating (flows between 600 and 1,500 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

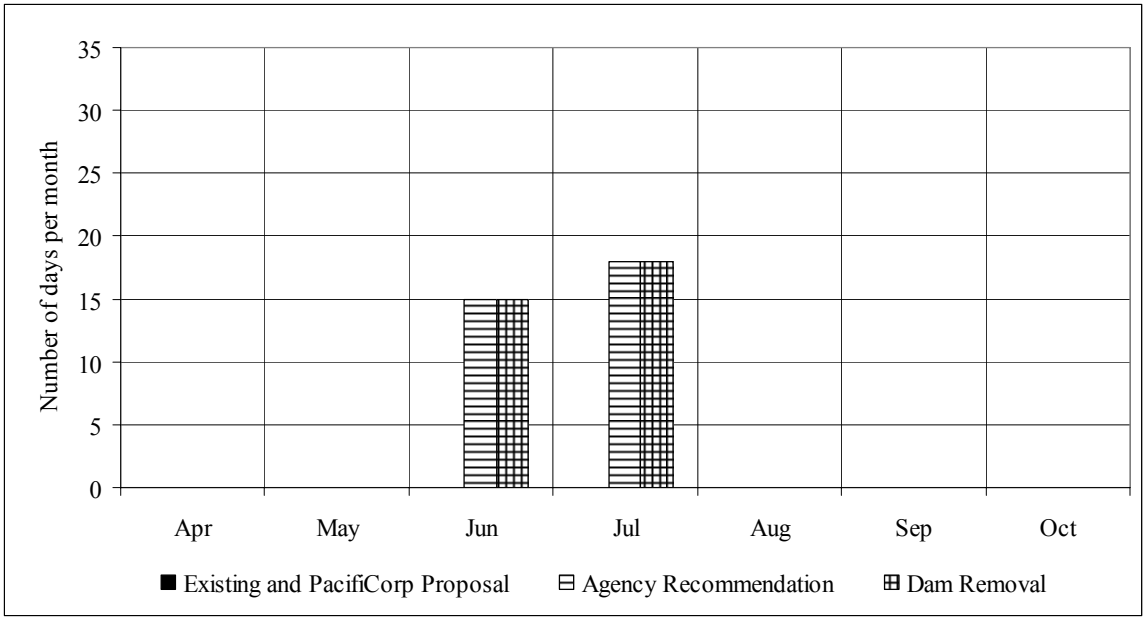

Figure 3-133. Below average water year type, Copco No. 2 bypassed reach acceptable range of flows for angling (flows between 50 and 600 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

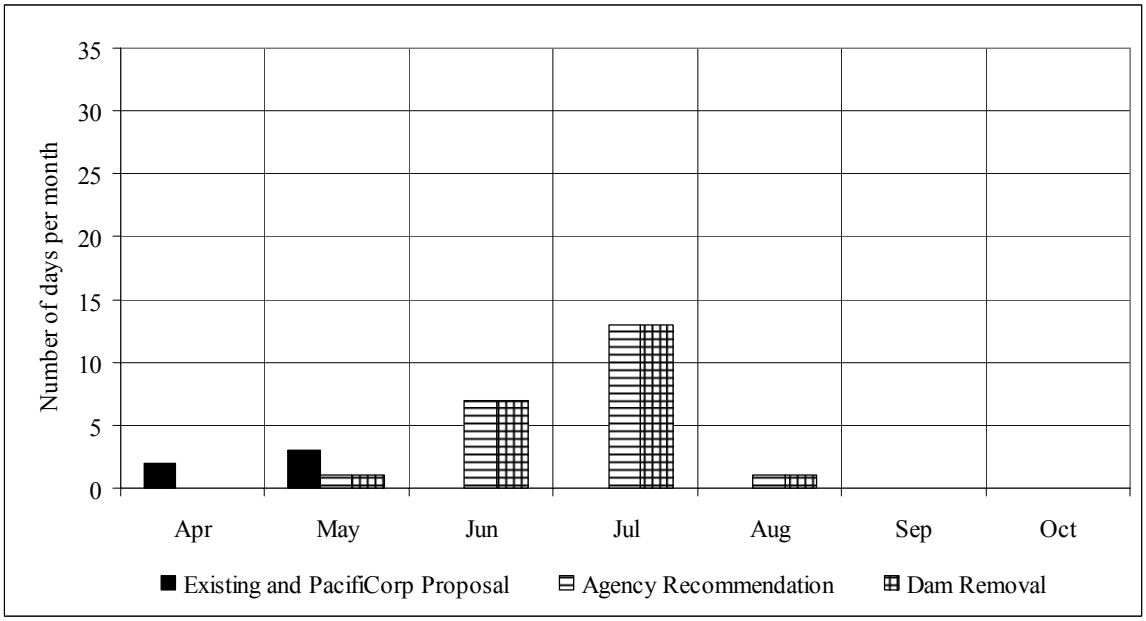

Figure 3-134. Average water year type, Copco No. 2 bypassed reach acceptable range of flows for angling (flows between 50 and 600 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

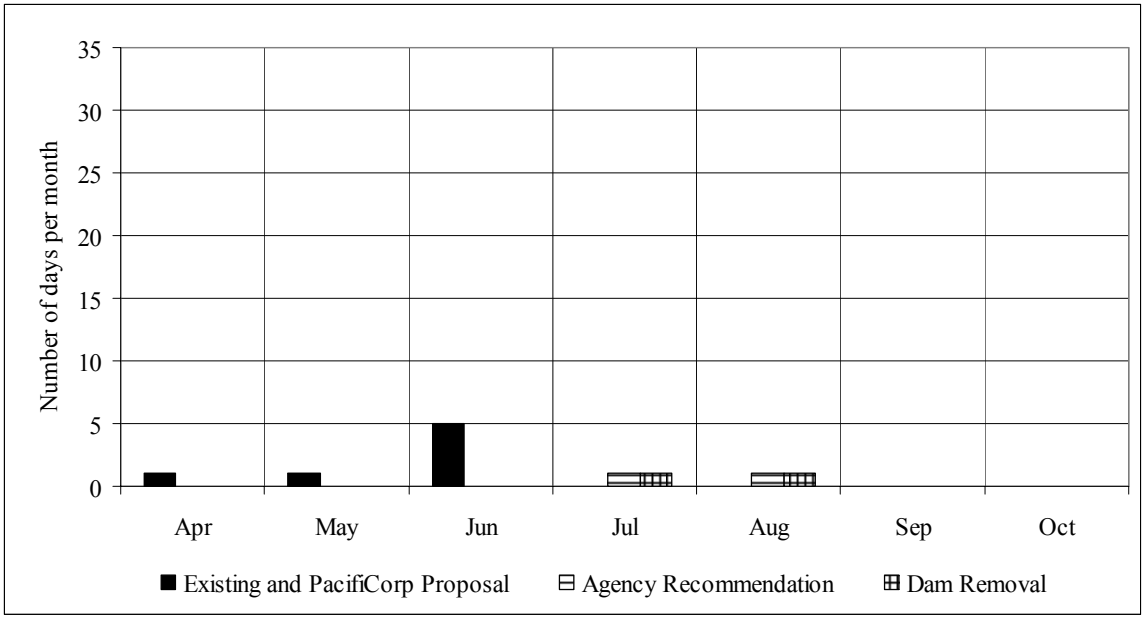

Figure 3-135. Above average water year type, Copco No. 2 bypassed reach acceptable range of flows for angling (flows between 50 and 600 cfs). (Source: PacifiCorp, 2005f; USGS, 2005)

Flow Measures, Below Iron Gate dam. Based on PacifiCorp's studies, standard whitewater boating opportunities would be provided at flows generally over 1,500 cfs, boat-based angling opportunities would be reduced at flows less than 1,000 cfs, and flows less than 800 cfs substantially reduce both angling and whitewater boating opportunities. Base flow requirements are set by the NMFS BiOp which are all above 1,000 cfs. This flow scenario would continue to provide boat-based angling and whitewater boating opportunities during May and June but the 1,000 cfs that would exist from July through October would reduce navigability and provide only technical whitewater boating opportunities. However, we do not consider this reduction in boating opportunities to be a project effect, because the flow regime downstream of Iron Gate dam is the result of the 2002 NMFS BiOp and pertains to operations at the Klamath Irrigation Project.

Flow Information Measures. Visitors often assess whether riverine conditions are such that they can participate and enjoy their planned activity before committing time or expense to a recreational experience. Whitewater boating and angling opportunities depend on the streamflow in the Klamath River. Although whitewater boaters and anglers make intuitive assessments of expected flows based on factors such as rainfall and snowfall accumulation and snowmelt patterns on unregulated rivers, the regulated flows of the project do not allow visitors to make these determinations on the Klamath River between Link River and Iron Gate dams. Considering access to the project waters requires a considerable travel distance, it is likely that some whitewater and angling opportunities may be forgone because visitors are not willing to commit based on uncertainty related to flows. Consequently, whitewater boating and angling opportunities could exist, but visitors may not take advantage of these conditions simply because they do not know if suitable flows are present. Conversely, after traveling hours to reach the project, visitors may find flows either too high or low to allow them to boat or fish.

Providing real-time information with seasonal and daily projections would provide visitors with sufficient information to plan trips. In this way, the public would know when conditions are suitable for their activities so available opportunities would not be forgone and visitors would not make unnecessary trips only to find unsuitable conditions. Considering PacifiCorp proposes to provide flow information as part of a RRMP program, this would be the appropriate place to address flow information needs. As

described in the draft RRMP, it is not clear whether PacifiCorp would provide real-time data, daily and seasonal projections, or which locations (gages) would be used to provide this information. Currently, the flow information on PacifiCorp's website is limited to the peaking reach and downstream of Iron Gate dam. The information for the peaking reach shows 4-days of hourly projected flows (the current and succeeding and 2 previous days), projected generation start times over the ensuing week, a planned summer operational schedule and planned outage schedule. The information for Iron Gate dam states the releases required by Reclamation are sufficient to provide whitewater boating use through the summer, but no actual flow information is provided. Considering there are also angling and boating opportunities on the other reaches, expanding this program to include the other project reaches would better enable visitors to make or adjust their plans. Real-time gage information from existing and proposed gages would be the most useful type of information for visitors, in addition to PacifiCorp's current practices described above (e.g., projected flows, generation times, and scheduled outages). Prompt posting of any changes to scheduled releases on PacifiCorp's flow-related website would enable commercial outfitters and others planning recreational trips to the project area to re-evaluate their proposed trip in light of altered flow conditions. We consider these informational elements would be essential to maximize whitewater boating and angling opportunities at the project. Further, the recommendations of others would also probably be accommodated by including these details in a flow information element of the Whitewater Boating and River-based Fishing Program in the final RRMP.

3.3.6.2.3 Development Decommissioning and Dam Removal

Numerous entities have recommended the removal of various project dams, as detailed in previous sections. Removal of the Fall Creek diversion dams would have little or no effect on recreational activities, and is not discussed further. Removal of Copco No. 2 dam would also have little or no effect on recreational activities, because access to the very small reservoir is limited and there are no recreational facilities at this development. In the event of the removal of one or more of the remaining four mainstem project dams, visitors would still be able to access the area for recreational pursuits, assuming most of the roads would likely remain. However the visitors' activities would be focused on a riverine setting rather than large bodies of flatwater. The three most likely affected activities would be flatwater recreation, river-based angling, and whitewater boating use.

Decommissioning and removing most mainstem project dams would eliminate the existing opportunities for reservoir-based recreational activities such as powerboating, waterskiing, swimming (lake), and boat angling. PacifiCorp identified 12 boatable lakes in the region similar in size to the four project reservoirs and it is likely existing project recreation visitors would relocate to these other reservoirs. Project recreational facilities constructed to accommodate reservoir recreation would likely remain; however, they would be located at a distance from a water setting which would reduce their attractiveness. Boat ramps would be unnecessary and present a strange appearance to visitors. Although the disposition of the recreational facilities would be a matter dealt with under a decommissioning plan, the decision on their fate should consider annual O&M funding since replacement would not be available from PacifiCorp. Although reservoir-based activities would be eliminated, decommissioning could improve water contact recreation by decreasing the frequency and magnitude of blue-green and other algae blooms (see section 3.3.2, *Water Resources*).

River angling opportunities would be created and likely improved if decommissioning improves the anadromous fishery in the Klamath River (see section 3.3.3, *Aquatic Resources*). Expanded river angling opportunities would likely attract increased numbers of anglers to the Klamath River potentially increasing business opportunities for angling guides.

PacifiCorp's bathymetric studies indicate most of the flowing sections of the Klamath River between Link River and Iron Gate dam provide suitable channels for whitewater boating. Although it is not known for certain, decommissioning and removal of project dams would probably create a channel where whitewater boating would be feasible, potentially providing additional opportunities for

commercial trips. The number of available days and suitability of such opportunities would depend on the flow (see 3.3.6.2.1, *River Recreation*). It is likely that natural flows would reduce the whitewater boating opportunities in the peaking reach because suitable flows would not be consistently or reliably provided during the summer months, which is the most popular time for this activity. Commercial whitewater boating companies could find it difficult to sustain a profitable business with this uncertainty and they could potentially go out of business. The decreased whitewater boating opportunities in the peaking reach would also diminish one of the ORVs of this designated Wild and Scenic River.

3.3.6.3 Unavoidable Adverse Effects

None.

3.3.7 Land Use and Aesthetic Resources

3.3.7.1 Affected Environment

3.3.7.1.1 Land Use, Ownership, and Management

Land Use

In its application, PacifiCorp mapped land uses within the existing and proposed project boundaries and 0.25 mile beyond the boundaries, using the following generalized categories (see PacifiCorp, 2004a, figure E8.1-3):

- Agriculture/grazing – generally intensive agricultural uses such as cropland or pasture, as well as grazing land.
- Open space and conservation – undeveloped lands not in active use; may include timber production, some grazing, developed and dispersed recreational uses; generally excludes residential.
- Hydro operations lands – lands used primarily for PacifiCorp hydroelectric operations facilities or maintenance activities.
- Recreation lands – designated recreational sites.
- Industrial/undeveloped – currently in industrial use or vacant but zoned industrial.
- Urban – fully developed, incorporated land.
- Residential – low-density rural residential, except for city of Klamath Falls, which is higher density.

The vast majority of the land in the study area is devoted either to agriculture/grazing or to open space and conservation. A small proportion is devoted to hydroelectric operations and recreation sites. Industrial/undeveloped and urban uses occur only in the city of Klamath Falls near East Side and West Side developments. Residential clusters occur in the city of Klamath Falls, in and around the community of Keno and the Keno Recreation Area, and along portions of Copco reservoir. A proposed subdivision east of Iron Gate reservoir, Iron Gate Estates, is mapped as undeveloped and is generally not in residential use except for isolated residences outside the 0.25-mile study area.

Land Ownership

The existing project boundary (see sections 2.1 and 2.2) encompasses lands owned by PacifiCorp, the Bureau of Land Management, Reclamation, the state of Oregon, Klamath County, the city of Klamath Falls, and a few private owners. The Forest Service also owns several parcels outside the project

boundary near Copco reservoir. In its report on land ownership and its roadway inventory (PacifiCorp, 2004d), PacifiCorp mapped land ownership within a study area defined to include lands inside the existing project boundary, along the Klamath River between developments, and outward 0.25 mile. Land ownership of project lands and lands in the study area varies among the developments as follows:

- Most of the land within the project boundary associated with East Side and West Side developments and Link River dam is owned by PacifiCorp, although some is owned by the United States (managed by Reclamation), Klamath County, the city of Klamath Falls, and private entities. Private lands predominate beyond the project boundary.
- At Keno development, the shoreline of Keno reservoir is primarily in private ownership, with some United States (managed by Reclamation) and state ownership, while the area near the dam is PacifiCorp and United States (under Reclamation management) property.
- PacifiCorp and private entities own the lands along the Klamath River in the Keno reach.
- PacifiCorp owns most of the land at J.C. Boyle development, concentrated along the reservoir and at the dam, while the project boundary also encompasses a few acres of private property and large tracts of federal land managed by the Bureau of Land Management that include Topsy Campground and much of the land along the access road, power canal, tunnel, and bypassed reach. The project boundary also encompasses state-owned land, which is limited to the Klamath River bed under J.C. Boyle reservoir.
- Federal ownership (managed by the Bureau of Land Management) predominates along the J.C. Boyle peaking reach of the Klamath River, which also includes some PacifiCorp and other private property. A small amount of Forest Service land lies within the 0.25-mile study area boundary.
- At the Copco developments, PacifiCorp owns the lands around the powerhouses, dams, and Copco No. 2 reservoir, while most of the land surrounding Copco reservoir is privately owned. The Bureau of Land Management also manages some federal lands near Copco reservoir and Copco No. 2 dam.
- PacifiCorp ownership predominates around Fall Creek development, including the diversion, creek, penstock, powerhouse, fish hatchery, and some access road and powerline rights-of-way. Bureau of Land Management-managed federal lands and private lands also occur within the 0.25-mile study area.
- PacifiCorp owns the land adjacent to the Iron Gate dam, fish hatchery, and powerhouse, as well as most of the land along the Iron Gate reservoir shoreline and the nearby transmission line right-of-way. The project boundary and 0.25-mile study area also includes some federal land (managed by Reclamation) and a small amount of private land.

PacifiCorp reports more specific land ownership data for its proposed project boundary. The proposed project boundary, containing 3,736.8 acres of submerged and non-submerged lands, encompasses lands adjacent to J.C. Boyle, Copco, Fall Creek, and Iron Gate developments, including the project reservoirs, hydroelectric generation facilities (dams and powerhouses), ancillary facilities such as fish hatcheries and river recreation areas, and certain transmission lines and access roads. PacifiCorp, the Bureau of Land Management, the state of Oregon, and a few private landowners own areas within the proposed project boundary. Table 3-102 shows land ownership within the proposed project boundary.

Table 3-102. Land ownership within the proposed project boundary. (Source: PacifiCorp, 2004a)

	Bureau of Land Management	State of Oregon	PacifiCorp	Other Private	Total[a]
J.C. Boyle	82.0	135.2	491.3	3.5	718.2
Copco	0.7	0.0	1,498.0	14.4	1,514.1
Fall Creek	9.7	0.0	83.2	9.3	102.2
Iron Gate	63.7	0.0	1,337.5	1.0	1,402.3
Total	156.1	135.2	3,410.0	28.2	3,736.8
Percent of Total	**4%**	**4%**	**91%**	**1%**	**100%**

[a] All values are approximate, derived from various GIS data sets. Row totals equal the sum of column entries +/- several acres.

Land Management

Given the number of parties owning lands within or near the project boundary, there are several relevant land management plans.

Bureau of Land Management Redding Resource Management Plan (RMP) and Record of Decision. The Redding RMP is a 15-year strategy addressing where and how the Bureau of Land Management will administer public lands under its jurisdiction within the Redding Resource Area, which includes Butte and Tehama counties and the majority of Shasta, Siskiyou, and Trinity counties. As such, it governs management of Bureau of Land Management's Mallard Cove Recreation Area at Copco reservoir and several Bureau of Land Management parcels crossed by transmission lines and Copco Road at Iron Gate reservoir. At Copco reservoir, Mallard Cove Recreation Area is not within the current project boundary, but would be included in the proposed project boundary. At Iron Gate reservoir, a portion of Copco Road crossing Bureau of Land Management land is within the current project boundary but not within the proposed project boundary; the transmission line corridors are within both current and proposed project boundaries. Other than a transmission line, none of the project facilities are on lands managed by the Redding District Bureau of Land Management. The RMP focuses on four planning issues: land tenure adjustment (where the Bureau of Land Management should provide long-term federal stewardship); recreation management (where and what mixture of recreation activities should be encouraged or discouraged); access (the ability of public users to physically access their public lands); and forest management (where forest management should be allowed given existing restrictions and changing land ownership).

In addition to governing management of the Bureau of Land Management lands at Copco and Iron Gate reservoirs, the Redding RMP also directs Bureau of Land Management policies with respect to the Klamath River from the California-Oregon border south to the end of the project,[145] which is in the Redding Resource Area's Klamath Management Area. Within the Klamath Management Area, the upper Klamath River is named as a resource with objectives to (1) maintain scenic quality, (2) improve riparian vegetation, (3) protect cultural resources, and (4) improve non-motorized recreation opportunities.

Bureau of Land Management Klamath Falls Resource Area ROD, RMP, and Rangeland Program Summary. The Klamath Falls RMP outlines the strategy for managing 212,000 acres in Klamath County, Oregon. The RMP provides guidance on how the Bureau of Land Management will use ecological, economic, social, and managerial principles to achieve healthy and sustainable natural systems and maintain the health of aquatic ecosystems. Eleven miles of the Klamath River, from the J.C. Boyle powerhouse to the Oregon-California border, are designated as a protected special area under the RMP, and new hydroelectric development is precluded there. Within this Klamath River Complex Special

[145] Bureau of Land Management lands in this area are near, but do not abut, the Klamath River.

Resource Management Area, there are several recreational sites and trails; the plan supports the existing cooperative management agreement with PacifiCorp for coordinated trail and facility development.

The RMP also directs the management of all Bureau of Land Management-administered land to meet visual quality objectives of various land classes. For further discussion of this topic, see section 3.3.7.1.3, *Aesthetic Resources*.

Bureau of Land Management Medford District ROD and RMP. The Medford RMP guides the Bureau of Land Management strategy for managing approximately 859,100 acres in Coos, Curry, Douglas, Jackson, and Josephine counties in Oregon. The ecosystem management strategy outlined by the plan comprised several major land use allocations, including late-successional reserves; adaptive management areas; general forest management areas and connectivity/diversity blocks; and a variety of special purpose management areas such as recreation sites, wild and scenic rivers, and visual resources management areas. The Spring Creek diversion facility is located in Jackson County within the Medford RMP area.

Forest Service Klamath National Forest Land and Resource Management Plan. The purpose of the plan is to coordinate and disclose programmatic management direction for the Klamath National Forest. The plan establishes the management direction and associated long-range goals and objectives for the forest; specifies the standards, timing, and vicinity of the practices necessary to achieve that direction; and establishes the monitoring and evaluation requirements needed to ensure that the direction is carried out. There are no lands of the Klamath National Forest within the project boundary, although there are some parcels near the east end of Copco reservoir. The plan designates those lands as late-successional reserve, and are managed to enhance habitat for late-successional and old growth-related species.

General Plan of Siskiyou County. The General Plan applies to the unincorporated area of Siskiyou County, California, and includes separate elements that were adopted over the course of several years, primarily in the 1970s. Elements cover a range of topics including land use, noise, conservation, energy, seismic safety, geothermal energy, and housing. The preservation of recreational and scenic lands is also emphasized. The General Plan guides land use policy within a large section of the project area, including Copco and Iron Gate reservoirs and the surrounding recreational lands.

Siskiyou County Zoning Ordinance. The Siskiyou County zoning ordinance guides land development in unincorporated portions of Siskiyou County by regulating allowable uses in various zones. Zones are grouped by six main uses—residential, commercial, industrial, agricultural, timberland, and open space. Hydroelectric facilities are subject to local review in part through the zoning code. The project area is located in three zones: AG-1, prime agricultural; AG-2, non-prime agricultural; and RR, rural residential.

Comprehensive Plan for Klamath County. Klamath County's Comprehensive Plan has three parts: policies, an atlas, and a land development code. The goals and objectives contained with the policy portion of the plan are recommended as a broad framework for future planning and development within the unincorporated area of the county. The Land Use Element of the plan describes 10 land use designations that are further broken down into implementing zones. Among other goals, the plan advocates conservation of agricultural and forest lands and preservation of open space and scenic rivers.

The land development code portion of the plan guides land development in unincorporated portions of Klamath County. Zones are grouped by six main uses—residential, commercial, industrial, exclusive farm use, forestry, and open space and conservation. Project facilities, including Keno dam, J.C. Boyle dam and powerhouse, and several recreation sites, are located in two zones: forestry (to protect forest ecosystems) and forestry/range zone (to promote the management and conservation of lands of mixed farm and forest use).

The Wild and Scenic Rivers Act. The Wild and Scenic Rivers Act (P.L. 90-542) and its amendments protect, in their free-flowing conditions, designated rivers and their immediate environments

that possess ORVs. ORVs include scenic, recreational, geologic, fish, wildlife, historic, cultural, or other similar values. Section 7(a) of the Wild and Scenic Rivers Act states that the Commission shall not license the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works under the FPA on or directly affecting any river designated as a Wild and Scenic River. The Wild and Scenic Rivers Act specifically does not preclude licensing of developments below or above designated wild, scenic, or recreational rivers if the development does not invade the area or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the designated reach.

The Wild and Scenic Rivers Act provides for management of a river corridor averaging 320 acres per mile (about 0.25 mile on each side of the river) based on the level of development existing at the time of designation. Management is applied to federal lands within the corridor and is based on three classifications: (1) Wild – segments that are unroaded and undeveloped; (2) Scenic – segments that are generally undeveloped, but may have occasional road crossings and riverside structures that are visually screened from the river; and (3) Recreational – segments that are generally developed, with parallel roads, bridges, and structures.[146]

As described in section 3.3.6.1.1, *Regional Recreational Setting*, two portions of the Klamath River are currently designated under the Wild and Scenic Rivers Act. In addition to ORVs related to recreation, the 11-mile "scenic" segment from J.C. Boyle powerhouse to the California-Oregon border was named for ORVs related to diverse wildlife, prehistoric sites, habitat for endangered species, historic places, scenery, and evidence of Native American traditional uses. The ORV for the lower portion of the Klamath River beginning below Iron Gate dam to the Pacific Ocean is anadromous fisheries (steelhead and salmon).

3.3.7.1.2 Road Management

PacifiCorp made a project roads inventory of roads and associated transportation-related structures (bridges, culverts, etc.) in two defined study areas: (1) a broad overall study area and (2) a smaller area that encompasses only the proposed project boundary. The broader study area includes a 0.25-mile buffer around all project reservoirs, facilities, the Spring Creek canal and access road, the southern access road to Copco No. 1 dam, and the access road to the Copco No. 2 water supply; the Klamath River from Link River dam to 0.5 mile downstream of Iron Gate Hatchery; the area between the canyon rims from J.C. Boyle dam to the eastern end of Copco reservoir; and all PacifiCorp-owned land adjacent to the project. In total, there are about 323 miles of roads in the broader study area. Table 3-103 summarizes the road mileage for which PacifiCorp has whole or partial responsibility within the existing project and proposed project boundaries. Sixteen percent (50.7 miles) of the road miles in the broad area study are within the existing project boundary, where PacifiCorp is solely responsible for maintaining 38 percent of the road miles (19.0 miles) and jointly responsible for about 13 percent (6.4 miles). About 13 percent (41.3 miles) of the roads in the broad study area are within the proposed project boundary, where PacifiCorp would be solely responsible for maintaining 54 percent of the road miles (22.4 miles) and jointly responsible for about 19 percent (7.7 miles).

[146]Designations are intended to protect the free-flowing conditions of the river and the ORVs. Logging, road building, new mining claims, developed campgrounds, and motorized access are generally prohibited on wild segments. On scenic segments, motorized use of trails may or may not be permitted. On recreational segments, all activities normally associated with public lands are permitted subject to the protection of the free-flowing conditions and ORVs of the designated river.

Table 3-103. Road mileage and maintenance responsibility within the Klamath River Project study area, existing project boundary, and proposed project boundary. (Source: PacifiCorp, 2004d)

Maintenance Responsibility	Miles Within Existing Project Boundary	Miles Within Proposed Project Boundary	Road Names
Link River Area			
PacifiCorp	1.83	0	Link River Trail, Mill Street, unnamed private road
Other	0.40	0	
Total	2.23	0	
Keno Reservoir/Keno Reach Area			
PacifiCorp	2.34	0	Keno Dam Road; unnamed OHV trail; Keno Recreation Area access road, area roads, and trail; gage station trail
Other	4.54	0	
Total	6.88	0	
J.C. Boyle Reservoir Area			
PacifiCorp	1.75	1.79	Pioneer Crossing recreation road and west recreation road, reservoir access road at Sportsman's Park, unnamed private road(s), unnamed OHV trail, J.C. Boyle dam access road, Red Barn access roads
Joint	0.86	0.55	Unnamed private road, Sportsman's Park access road and boat launch
Other	3.31	2.76	
Total	5.92	5.10	
J.C. Boyle to Stateline Area			
PacifiCorp	4.73	4.86	J.C. Boyle Dam Road/Spring Island Road, J.C. Boyle canal access road, unnamed private road(s), unnamed transmission line access road, powerhouse river access road, J.C. Boyle tunnel access road
Joint	4.69	4.49	Spring Island Road, unnamed private road(s), jointly maintained hydro road, Bureau of Land Management Klamath River Campground road
Other	6.13	0.07	
Total	15.55	9.42	
Stateline to Copco Reservoir Reach			
PacifiCorp	0	0.30	Stateline Take-out road, Shovel Creek access road, Fishing Access Site 6 trail, Fishing Access Site 5 parking, Fishing Access Site 3 trail and parking, Fishing Access Site 2 trail, Fishing Access Site 1 road
Other	0.01	2.21	
Total	0.01	2.51	

Maintenance Responsibility	Miles Within Existing Project Boundary	Miles Within Proposed Project Boundary	Road Names
Copco Reservoir Area			
PacifiCorp	1.83	2.76	Unnamed transmission line access roads, Mallard Cove recreation road, Copco No. 2 Village Road, unnamed private roads, Copco No. 2 powerhouse road, Copco No. 2 dam north access road, cinder quarry road, Copco Cove Road
Joint	0.02	0.02	Copco Road
Other	0.23	0.82	
Total	2.08	3.60	
Fall Creek/Spring Creek Area			
PacifiCorp	0.49	1.98	Unnamed private road(s)
Joint	0.01	1.33	Unnamed private road(s), Spring Creek Road, Fall Creek access road, Fall Creek Trail, Copco Road
Other	0.01	0.36	
Total	0.51	3.67	
Iron Gate Reservoir Area			
PacifiCorp	6.05	10.72	Unnamed private road(s); Copco Village Road; Schoolhouse Road; Copco Village residence, powerhouse, bunkhouse, water tower, dump, and communications tower roads; Copco Canyon access road; Copco No. 2 dam south access road ; Copco No. 2 Village south access road; Fall Creek recreation road; unnamed transmission line access roads; Jenny Creek recreation road; Camp Creek access, pull off, campground, and day-use area roads; Wanaka Springs Road; Juniper Point recreation road; Mirror Cove Road; Old Quarry Road; Overlook Point Road; Long Gulch Recreation Area road; Iron Gate Fish Hatchery boat launch road; Iron Gate dam access road
Joint	0.87	1.29	Copco Road, Iron Gate dam access road, Iron Gate Estates road
Other	10.61	4.94	
Total	17.53	16.95	
Total Area			
PacifiCorp	19.02	22.42	
Joint	6.44	7.68	
Other	25.22	11.17	
Total	50.68	41.27	

3.3.7.1.3 Aesthetic Resources

The study area for the visual resource studies includes PacifiCorp facilities and operations on the Klamath River from Link River in the city of Klamath Falls to the Iron Gate Hatchery, just downstream of Iron Gate dam. The topographic characteristics of the project area vary widely from east to west. Along the northernmost, eastern edge of the project area, the Klamath River borders remnants of central Oregon's Modoc Plateau province. The river flows through a broad, flat valley that gradually transitions

to a narrow channel as it crosses the low, rolling ridges of the Cascade Mountains. In the central section of the project, upstream of J.C. Boyle dam, the topography changes dramatically, dropping rapidly into the 1,000-foot-deep upper Klamath River Canyon. The ruggedness of the terrain exemplifies the surrounding landscape, where nearby mountain peaks often reach 5,000 feet in elevation. Less than 5 miles downstream of J.C. Boyle dam, the canyon and neighboring ridges gradually become flatter and wider as the river flows southwesterly across the state line and into Copco reservoir. Here, along the project's western edge, the topography surrounding Copco and Iron Gate reservoirs is open and rolling.

As the river passes through the Cascade Mountains, the upper Klamath River Canyon represents a transition from the desert landscape to the east to a mountainous landscape to the west. The steep-walled canyon is the predominant visual element in the region. As it flows through the deep gorge, the river changes from slack, slow-flowing water in the broad, flat valley to a torrent of cascading whitewater.

Within the visual resource study area, PacifiCorp evaluated the way in which project features and operations fit into the overall visual landscape using the following three-step process: (1) identifying the Bureau of Land Management visual resource management classifications applicable within the study area; (2) defining viewpoints from which project facilities and operations could be seen; and (3) evaluating whether project facilities and operations, when seen from the viewpoints, conform to the objectives of the management classification in which they are found (PacifiCorp, 2004k).

As noted above, project facilities fall under three Bureau of Land Management RMPs: Klamath Falls Resource Area, Medford, and Redding District. In the RMPs, the Bureau of Land Management identifies two visual resource management classifications that describe acceptable level of change to the landscape. In Class II (retention areas), the level of change to the characteristic landscape should be low relative to the existing character of the landscape. In Class III (partial retention areas) the level of change to the characteristic landscape should be moderate relative to the existing character of the landscape.

PacifiCorp then identified key observation points to represent typical public viewing locations. The locations provide representative views for members of the public seeing project facilities, the river reaches, and the reservoirs from developed vistas and roads in the project area. PacifiCorp designated 57 key observation points, including 6 in the Link River area, 7 from Keno reservoir to the J.C. Boyle reservoir, 9 in the J.C. Boyle bypassed reach, 8 in the Hell's Corner reach (the river between J.C. Boyle powerhouse downstream to Copco reservoir), 7 in the Copco reservoir area, 5 in the Fall Creek area, 12 in the area of Iron Gate reservoir, and 3 downstream of Iron Gate dam.

Project Facilities

In its *Land Use, Visual, and Aesthetic Resources Final Technical Report* (PacifiCorp, 2004k), PacifiCorp characterized project facilities using Bureau of Land Management visual resource management (VRM) methods, and compared the characterizations to applicable VRM objectives. PacifiCorp (2004k) reported that all but four of the project facilities are in areas designated as Class III,[147] where management activities may attract attention, but should not dominate the view of the casual observer. The four project features that are located in Class II areas, where non-native elements should not attract the attention of the casual observer, are not consistent with the VRM class.

The four facilities noted by PacifiCorp (2004k) in Class II areas—the J.C. Boyle dam, powerhouse, penstocks, and transmission line—are not consistent with the VRM classification because they attract the attention of the casual observer. The dam's size makes it very apparent in the landscape despite the fact that its line follows the site's topography. The powerhouse and penstocks are prominent in the landscape because of their color and strong lines, which contrast with the natural setting. The

[147]The Class III areas include those designated Class III by an RMP and those for which the Bureau of Land Management has not given a specific VRM class.

transmission line is noticeable because it crosses a long distance and rises above the other features in the landscape. In its comments on the draft EIS, Interior comments that another project feature, the J.C. Boyle bypass canal, is located in a Class II area and is incompatible with that VRM class.

Five project facilities in Class III areas dominate the view of the casual observer and are therefore not considered consistent with their VRM class: West Side powerhouse, Copco No. 1 dam and powerhouse, Copco No. 2 powerhouse, Fall Creek powerhouse, and Iron Gate Hatchery and fish ladder. The five associated key observation points are located close to the facilities in question, so that the facilities tend to dominate the view because of their size and prominence in relation to the position of the viewer. Two of these facilities—West Side powerhouse and Iron Gate Hatchery and fish ladder—are much less prominent from a slight distance.

The remaining facilities, including dams and powerhouses, transmission lines, Fall Creek hatchery facilities, and recreation and trail areas, either fit within the profile of the surrounding area or are seen from a distance or for a short period of time. These facilities and areas do not dominate the view of the casual observer.

River Reaches

The key observation point assessment of free-flowing river reaches from Link River to downstream of Iron Gate dam found the same general characteristics in all the reaches, although the aesthetic differences between high flows and low flows varied depending on the breadth and depth of the water and the variety of physical features in each reach. At low flows, rocks and vegetation are visible at the channel edges, and hydraulic expression is mostly limited to areas where rocks extend above the water surface. As flows increase, fewer rocks and less vegetation are visible. At some locations, hydraulic expression increases as the flow increases.

Reservoirs

PacifiCorp documented visual characteristics of all the project reservoirs except Keno reservoir under high pool and low pool conditions. Because the water level varies little, PacifiCorp documented Keno reservoir visual characteristics only under average pool conditions. At J.C. Boyle reservoir and Copco reservoir, PacifiCorp also documented visual characteristics at the very low levels seen only during maintenance drawdowns.

At Keno reservoir, the views are dominated by large expanses of flat blue water. Along most of the shoreline, shrubs and grasses border the reservoir.

At J.C. Boyle reservoir, the differences between low and high pool levels at the three associated key observation points are not great because of the relatively small change in water levels. Some differences, however, are visible. At low pool, all three views of the reservoir show an open expanse of relatively flat water with light green vegetation growing up from the lake bottom. Shoreline views vary according to the makeup of the shoreline (dirt, rock face, etc.). From the Topsy Campground, J.C. Boyle dam and a disturbed area next to the dam stand out from the rest of the view. At high pool, the light green vegetation is no longer visible, and less of the shoreline is visible. Under maintenance drawdown conditions, a large area of exposed lake bottom dominates the view.

During high pool conditions at Copco reservoir, as seen from Mallard Cove and Copco Cove recreation areas, a small area of nearshore lake bottom is exposed. The area of exposed lake bottom is larger at low pool and the visual quality is lower. As at J.C. Boyle reservoir, a large area of exposed lake bottom dominates the view under maintenance drawdown.

PacifiCorp documented views at Iron Gate reservoir from six recreation areas. At high pool, little or no lake bottom is exposed along the shoreline of the recreation areas. At low pool, more lake bottom is

visible at all six key observation points; features such as sandbars and driftwood are visible at some. Similar to the other reservoirs, the visual quality is lower at low pool than at high pool.

3.3.7.2 Environmental Effects

3.3.7.2.1 Land Management and Use

PacifiCorp does not propose any measures that address land management and use. Interior recommends that PacifiCorp enter into a cooperative management agreement with the Bureau of Land Management to ensure that management of Klamath River lands and resources would not be compromised by project operations. Under this recommendation, PacifiCorp would work with the Bureau of Land Management to (1) manage riparian and aquatic habitats; (2) maintain and enhance species of special concern and their habitats; (3) maintain and enhance recreation and scenic resources and provide for safe recreational experiences; (4) manage deer winter range; (5) manage water resources to meet applicable standards; (6) protect and interpret archaeological resources and cultural values; and (7) provide a presence to eliminate or minimize unsafe and unlawful activities.

The Bureau of Land Management also specifies several conditions related to land use, and PacifiCorp offers several alternative conditions. Table 3-104 presents a summary of the modified land use conditions specified by the Bureau of Land Management in its January 30, 2007, filing and alternative conditions submitted by PacifiCorp that we address in our environmental analysis.[148]

Our Analysis

In its license application, PacifiCorp states that the existing project facilities are not in conflict with applicable land use and resource management plans and are either consistent with current zoning or allowed as conditional uses. PacifiCorp also states that the consistency with agency resource management plans, primarily Bureau of Land Management plans, arises from the fact that the project provides for some land uses called for in the plans (for example, passive and active recreation) and does not interfere with others (for example, forestry and agriculture).

Interior, in its support of a cooperative management agreement between the Bureau of Land Management and PacifiCorp, indicates that a memorandum of understanding among the Bureau of Land Management, PacifiCorp, state and federal wildlife management agencies, and landowners is in effect for the Upper Klamath River, and that in 2001, PacifiCorp evinced interest in a similar arrangement for lands downstream of the J.C. Boyle powerhouse near the Oregon-California border and lands between the border and Copco reservoir. Interior states that some lands are encumbered with licensed facilities, are directly or indirectly affected by the project, and are not proposed for inclusion in the proposed project boundary. While objecting to the omission of such lands from the project boundary (see section 3.3.7.2.3, *Project Boundary*), Interior recommends that the subject lands be covered by a cooperative management agreement. In our view, the coordination needed to develop and implement a cooperative management agreement could help ensure the protection of Bureau of Land Management and project resources. However, we also note that the action may be redundant, because the actions noted in Interior's recommendation would be addressed in other, recommended resource-specific management plans.

[148] Several of the Bureau of Land Management's conditions and PacifiCorp's alternative conditions are primarily administrative in nature; as such, we do not address them further in this EIS.

Table 3-104. Specified and alternative land use conditions. (Source: Letter from Interior to the Commission, filed January 30, 2007, and letter from PacifiCorp to Interior dated April 27, 2006)

Bureau of Land Management Specified Condition	PacifiCorp Alternative Condition[a]
For any proposed activity to be implemented by PacifiCorp on or affecting lands administered by the Bureau of Land Management to be added to the project boundary, PacifiCorp should request and obtain a Bureau of Land Management use authorization prior to conducting the activity. PacifiCorp should fund any required environmental analysis related to the issuance of the use authorization, as determined by the Bureau of Land Management. As part of the request for the use authorization, PacifiCorp may provide environmental analysis of the proposed action that meets Bureau of Land Management requirements for implementing NEPA in existence at the time the request is made, including changes in states or regulations governing Bureau of Land Management NEPA procedures. PacifiCorp may also refer to or rely on any previous NEPA analysis for the proposed measure to the extent the analysis is currently applicable, as determined by the Bureau of Land Management. The use authorization may contain stipulations for fire protection, spoils disposal, hazardous materials, safety or other standard use authorization measures consistent with the requirements in effect at the time for implementation of similar actions on lands administered by the Bureau of Land Management.	Restricts consultation to proposed activities on Bureau of Land Management reservation lands within the project boundary, and deletes the "beyond the scope of the license" phrase.
PacifiCorp should prepare site-specific plans for Bureau of Land Management approval for PacifiCorp activities required by the license that could affect Bureau of Land Management-administered lands or resources. The site-specific plans would include, at a minimum: (1) a map showing the location of the proposed activity; (2) the land use allocation and management designation including standards and guidelines for the area of the proposed activity; (3) site-specific designs for the proposed activity; (4) proposals for project-specific mitigation measures, including, but not limited to, applicable measures addressing safety, inspections, spoils disposal, hazardous substances, and restoration needs; (5) proposals for implementation and effectiveness monitoring necessary to meet standards and guidelines; and (6) data from surveys, biological evaluations, or consultation required by regulation and as applicable to activities on Bureau of Land Management-administered lands.	Adds a "reasonable discretion" phrase to PacifiCorp's need to obtain written approval from the Bureau of Land Management prior to changing the location of a project feature, and restricts the scope to Bureau of Land Management reservation lands within the project boundary
Upon Bureau of Land Management approval of site-specific plans, PacifiCorp should conduct any additional environmental analysis deemed necessary by the Bureau of Land Management to ensure consistency with statutes, regulations, and policies, including the National Historic Preservation Act, Archaeological. Resources Protection Act, Native American Grave Protection Act, Clean Air Act, Clean Water Act, ESA, and the Bureau of Land Management direction in its NEPA Handbook. As part of the site-specific plan, PacifiCorp may provide environmental analysis of the proposed activity that meets Bureau of Land Management requirements for	PacifiCorp would eliminate this condition.

Bureau of Land Management Specified Condition	PacifiCorp Alternative Condition[a]
implementing NEPA at the time the request is made. PacifiCorp may also refer to or rely on any previous site-specific NEPA analysis for the proposed activity to the extent the analysis is currently applicable, as determined by the Bureau of Land Management. PacifiCorp should obtain written authorization of the Bureau of Land Management before implementing the activity.	
PacifiCorp should restore Bureau of Land Management-administered lands affected by the project to a condition satisfactory to the Bureau of Land management prior to any surrender of the project license. At least one year in advance of license surrender, PacifiCorp should file with the Commission a restoration plan approved by the Bureau of Land Management. The plan should identify project-related improvements to be removed, restoration measures, and time frames for implementation and estimated restoration costs.	
Prior to abandonment of any project-related facilities on or affecting Bureau of Land Management-administered lands, including impacts due to change s in the project boundary from that in the original license, PacifiCorp should restore Bureau of Land Management lands to a condition satisfactory to the Bureau of Land Management. At least 1 year in advance of the abandonment of these project-related facilities, PacifiCorp should file with the Commission a restoration and maintenance plan approved by the Bureau of Land Management. The plan should identify, at a minimum, improvements that would be removed, improvements abandoned but not removed restoration and maintenance measures, time frames, and costs.	Limits the scope of this condition to Bureau of Land Management lands within the project boundary, indicates that the restoration of such lands would not be to a level that is greater than surrounding lands, agrees to provide information to the Bureau of Land Management that PacifiCorp has the ability to fund restoration work specified in the restoration plan, but not by an audit if the information provided is sufficient to document PacifiCorp's financial ability to fund decommissioning. After receiving this information, PacifiCorp agrees that the Bureau of Land Management could request an audit. PacifiCorp recommends deleting the Bureau of Land Management 's provision that if the license is transferred, that PacifiCorp should guarantee that the transferee or licensee would provide for the costs of surrender and restoration.

Bureau of Land Management Specified Condition	PacifiCorp Alternative Condition[a]
PacifiCorp should consult with the Bureau of Land Management at least annually and prepare a report on the status of implementing conditions of the license including, at a minimum, those that could affect Bureau of Land Management-administered lands and resources. The report should include, but is not limited to, monitoring results from the previous year regarding effectiveness of environmental measures, a review of non-routine maintenance, discussion of foreseeable changes in project facilities or operations, discussion of any needed revisions or modification to plans approved as part of this license, and discussion of elements of current year maintenance plans, such as road maintenance.	Limits the scope of the annual consultation with the Bureau of Land Management to Bureau of Land Management lands within the project boundary.
Within 60-days of issuance of the report to the Bureau of Land Management, PacifiCorp should file the record of consultation and any Bureau of Land Management comments and recommendations with the Commission.	Eliminates the Bureau of Land Management 's reservation of rights to change its 4(e) conditions after notice, comment, and administrative review.
PacifiCorp should consult with the Bureau of Land Management on an as-needed basis to identify and resolve potential conflicts with Bureau of Land Management policy and direction prior to initiating activities on Bureau of Land Management-administered lands.	

[a] PacifiCorp's alternative land management conditions were based on the Bureau of Land Management's preliminary land management conditions, filed March 27, 2006, and were addressed in the draft EIS. In many cases, the Bureau of Land Management modified conditions filed January 30, 2007, no longer include the elements or language with which PacifiCorp took issue in its alternative condition. However, PacifiCorp has not withdrawn its alternative land management conditions, and they are therefore addressed in this EIS where they are applicable.

The Bureau of Land Management specifies several other measures that include, among other things (1) procedures for applying for use authorization for activities on or affecting Bureau of Land Management-administered lands, including procedures for environmental analysis, (2) the need for site-specific plans for activities that could affect Bureau of Land Management lands, and (3) the need for compliance with NEPA standards and other federal laws when conducting activities on Bureau of Land Management lands. In support of these conditions, the Bureau of Land Management cites its need to ensure compliance with laws, regulation, policies, and land use plan decisions that the Bureau of Land Management is responsible for upholding or implementing. PacifiCorp's alternative conditions would provide a narrower application of the first two specifications (see table 3-104), and eliminate the condition related to compliance with NEPA and other federal laws. PacifiCorp supports its position by noting that the Bureau of Land Management's 4(e) conditioning authority applies only to Bureau of Land Management reservation lands within the project boundary, not any other lands, and indicates that the Commission, not the Bureau of Land Management, is responsible for NEPA compliance for the project.

With respect to activities on Bureau of Land Management lands and Bureau of Land Management's responsibility to uphold or implement certain laws, this EIS addresses all known ground-disturbing and habitat-altering activities that would be expected to occur under the term of a new license, and addresses the issue of consultation with the Bureau of Land Management as needed for specific actions. Under the Bureau of Land Management's modified conditions, this EIS or other NEPA documentation could be submitted by PacifiCorp in support of its application for use authorization on Bureau of Land Management-administered lands. If unforeseen future events result in the need for ground-disturbing actions that are not addressed in this NEPA document, then such ground-disturbing actions would require environmental review under the provisions of NEPA and would require PacifiCorp to file an application to amend its license with the Commission. The Commission would then assess the potential environmental effects of the proposed action and, if appropriate, prepare an environmental assessment (or EIS for substantive actions) under NEPA provisions. Consultation with resource agencies would be part of that separate proceeding. The Bureau of Land Management's conditions in this regard appear to clarify the way in which the Commission's NEPA requirements may be used to address the Bureau of Land Management's needs for environmental analysis of project-related activities affected lands managed by that agency.

With respect to the area to which the Bureau of Land Management's conditions properly apply, in its proposed alternatives to Interior's preliminary section 18 prescription and section 4(e) conditions, filed with the Commission on April 28, 2006, PacifiCorp indicates that there are about 7,599 acres of Bureau of Land Management-managed lands within the Klamath River Canyon area between J.C. Boyle dam and Copco reservoir, of which only about 490 acres are within the project boundary. PacifiCorp states that the Bureau of Land Management has 4(e) conditioning authority over only a fraction of that 490 acres. Although we do not address the legal question in this environmental analysis, we note that the Bureau of Land Management's modified conditions, as well as PacifiCorp's alternative conditions, would apply only within the area over which the Bureau of Land Management has 4(e) conditioning authority, rather than over any broader area.

The conditions of any new license would apply to any project-related activities, regardless of whether they are within the project boundary. Project-related activities occurring on lands outside the project boundary could include, for example, project-related construction vehicles using roads that are not primarily related to the project, and are therefore outside the project boundary. Such project-related activities would be covered by the same license requirements that are applicable within the project boundary. PacifiCorp's alternative conditions, if applied to all project-related activities, would provide a mechanism for coordination between the Bureau of Land Management and PacifiCorp with regard to activities covered by the license, and would thereby facilitate protection of Bureau of Land Management and project resources.

The Bureau of Land Management specifies conditions to be fulfilled by PacifiCorp in the event of license surrender, abandonment of facilities, or project boundary change, while PacifiCorp's alternative condition would limit this condition to Bureau of Land Management reservation lands within the project boundary and recommends other restrictions or clarifications of the condition (see table 3-104). In our consideration of this condition and alternative condition, we note that if PacifiCorp proposes in the future to surrender its project license, abandon any project facility, modify the project boundary, amend its project license, or transfer its license to another entity, a license surrender, decommissioning, amendment, or transfer proceeding would be required. Details regarding standards of restoration would be addressed in that proceeding and in the associated decommissioning plans. Thus, such future actions do not need to be addressed during this relicensing.

The Bureau of Land Management specifies procedures that address annual consultation regarding the status of implementing conditions related to Bureau of Land Management lands, while PacifiCorp submitted an alternative condition that would limit the scope to Bureau of Land Management reservation lands within the project boundary (see table 3-104). In our estimation, the reporting and consultation requirements included in resource specific plans proposed, recommended, or specified by various entities would provide ample opportunity to review progress toward meeting various objectives in appropriate resource areas without the need for additional annual consultation with the Bureau of Land Management beyond that specified in specific plans. As such, the annual consultation specified by the Bureau would likely be redundant with other consultations.

In a condition related to annual consultation, the Bureau of Land Management specifies that PacifiCorp file a record of the consultation with the Commission. This is primarily an administrative issue, although we note that the Commission would want to be informed of any substantive outcomes of such consultation.

3.3.7.2.2 Road Management

The roadway inventory presented in section 3.3.7.1.2, *Road Management*, indicates the roads and road mileage within the existing and proposed project boundaries for which PacifiCorp has complete or partial maintenance responsibilities. PacifiCorp proposes to use its proposed Project Roadway Management Plan (PacifiCorp, 2004d), filed with the Commission on November 2, 2004, to guide its management of project-related transportation facilities within the proposed project boundary during the term of a new license. The purpose and intent of the roadway management plan is to:

- identify roads and bridges necessary for the continued operation of the project through the term of a new license;
- identify transportation-related operation and maintenance activities required for the continued operation of the project that occur within the proposed project boundary;
- identify use- and cost-sharing agreements for project and project-related road and bridge operation and maintenance by PacifiCorp and other agencies/stakeholders responsible for roads and bridges within the proposed project boundary;
- provide for continued protection of natural and cultural resource along project roadway corridors;
- identify appropriate standards for the maintenance of project-related roads and bridges; and
- identify relevant policies and prescriptions included in county, state, and federal transportation plans applicable to roads in the project area.[149]

[149]PacifiCorp indicates that these plans include (1) the Oregon Department of Transportation Routine Road Maintenance Water Quality and Habitat Guide: Best Management Practices; (2) the Bureau

PacifiCorp proposes to facilitate long-term coordination and budgeting between PacifiCorp and other transportation-related management entities (that is, those individuals and agencies jointly responsible for maintaining project roads) by annually preparing a rolling 5-year transportation action plan to help guide anticipated activities for normal or recurrent general maintenance, as well as major maintenance. As proposed by PacifiCorp, the transportation action plan would summarize the project-related road, bridge, and major culvert maintenance and capital improvements performed during the previous year and planned for the current year and subsequent 3 years. The plan also would document incurred and planned costs, including the allocation of joint costs, such as between PacifiCorp and the Bureau of Land Management.

In its modified terms and conditions, the Bureau of Land Management specifies that, within 6 months of license issuance, PacifiCorp should file a project roads inventory analysis for project-related roads that cross Bureau of Land Management land within the geographical scope of the *Study Area Roadway Inventory Analysis and Project Roadway Management Plan – Klamath Hydroelectric Project* (PacifiCorp, 2004d). The Bureau of Land Management also specifies that, within one year of license issuance, PacifiCorp should, in consultation with the agency, prepare a draft road management plan and file the plan with the Commission for approval. The purpose of the plan would be to facilitate coordination of transportation maintenance and management, continue to provide for public safety, minimize potential damage to big game winter range, manage transportation access consistent with Bureau of Land Management-management objectives, coordinate OHV management, minimize the spread of noxious weeds, restore hydrologic function in areas that have been affected by use of Bureau of Land Management roads for project purposes, and continue to protect cultural resources. The Bureau of Land Management specifies that the road management plan should include all roads that cross lands administered by the agency that are identified in the inventory analysis that sustain project-related uses, including recreation, and that it include, at a minimum, the items specified in the final license application (PacifiCorp, 2004a) as follows:

- identify roads, bridges, culverts and other transportation-related structures necessary for project-related activities, including project-related recreation;
- identify transportation-related operations and maintenance activities required for the continued operation of the project;
- identify transportation-related activities required to address project-related recreation uses;
- include provisions for use and cost-sharing agreements for project and project-related transportation-related structures;
- identify PacifiCorp's share for management and maintenance of Bureau of Land management roads affected by the project;
- identify Bureau of Land management roads previously used but which are no longer necessary to operate and maintain the project or used for project-related recreation, and include plans for decommissioning there roads as appropriate;
- provide for continue protection of natural and cultural resources along project-related roadway corridors;
- identify appropriate standards for the maintenance of project-related roads and other transportation-related structures;

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of Land Management Western Oregon Transportation Management Plan; and (3) the Bureau of Land Management Draft Upper Klamath River Management Plan, Environmental Impact Statement, and Resource Management Plan Amendments.

- identify and implement Best Management Practices for maintaining and protecting cultural resources, vegetation resources (including management for noxious weeds), aquatic resources, and minimizing soil erosion; and
- identify relevant Bureau of Land management policies for transportation management of Bureau of Land Management roads affected by project-related activities.

PacifiCorp's alternative condition would limit the scope of this condition to Bureau of Land Management lands within the project boundary. Consistent with the Bureau of Land Management's modified condition, PacifiCorp's alternative calls for finalizing the plan in consultation with the Bureau of Land Management prior to submitting the final plan for Commission approval.

Our Analysis

PacifiCorp's proposal and the Bureau of Land Management's modified condition have many common elements, including intentions to (1) clarify goals, objectives, and standards among the parties; (2) provide for continued protection of natural and cultural resources; and (3) identify cost-sharing agreements needed to implement the plan. PacifiCorp's completed inventory (2004) also already addresses some of the Bureau of Land Management's goals, including identifying Bureau of Land Management roads necessary to operate and maintain the project and roads previously used but no longer needed to operate and maintain the project. PacifiCorp's alternative condition also indicates intentions to consult with the Bureau of Land Management before finalizing the plan.

In our analysis, we considered both the content of the draft plan and the area to which it would apply. Consulting with the Bureau of Land Management following issuance of any license would help finalize PacifiCorp's existing plan to reflect input from the Bureau of Land Management and other appropriate agencies. The final content of the plan could be determined during consultation.

In our view, all of the elements of PacifiCorp's proposed plan and the Bureau of Land Management's modified condition would be appropriate for inclusion in the final plan, within the limits of each party's authority. In its comments on the draft EIS, PacifiCorp states that its proposal to exclude from the project boundary several roads that are within the existing project boundary is based on a determination that the roads are not necessary for project operation and maintenance. In the rationale for its modified condition, the Bureau of Land Management states that the proposed project boundary revision excludes numerous miles of road that PacifiCorp has previously been required to manage and maintain, and that the road management plan must include recommendations on how those roads should be managed, including options for maintenance, improvement, or closure.

With respect to the area to which the plan should apply, we note that PacifiCorp is responsible for project-related effects whether within or outside the project boundary, although in general, PacifiCorp's responsibilities should be closely aligned with the project boundary (see the following section). At the same time, the Bureau of Land Management may impose conditions only within the area over which it has legitimate 4(e) conditioning authority. Only roads necessary for project operation and maintenance would be PacifiCorp's responsibility.

3.3.7.2.3 Project Boundary

In its response to the Commission's ready for environmental analysis notice, Interior stated that several areas that PacifiCorp excludes from the proposed project boundary should instead be within the project boundary. Interior makes the following comments about specific areas.

(1) Powerhouse Road - The proposed project boundary excludes 5.6 miles of the (J.C. Boyle) Powerhouse Road, but the southern portion of the road between the Spring Island boat launch and the junction with Topsy Grade should be included because:

a. the road is adjacent to the Klamath River and was withdrawn in 1959 for the project;

b. the road continues to provide needed access for operation and maintenance of PacifiCorp's transmission lines; and

c. regular maintenance of the road is required to prevent resource degradation and provide access to recreation sites associated with the project (i.e., Spring Island boat launch).[150]

(2) J.C. Boyle Bypassed River Reach – Interior states that the bypassed reach should be included in the project boundary because it would continue to be necessary for operation and maintenance of the project. In particular, Interior notes that both the J.C. Boyle power canal and the emergency spillway are upslope of the bypassed reach, and both have required major repair since 2001 in response to spillway overflows and canal damage that have caused hillslope erosion, river bank erosion, and sediment deposition that have directly affected aquatic and riparian habitat. Corrective measures included excavation of eroded material on the alluvial fan, surface stabilization measures (seeding, mulching), and removal of eroded material from the floodplain. Interior indicates that the same forces that caused these events would continue during the entire term of a new license, creating continuing project-related affects and requiring continuing maintenance and restoration by PacifiCorp.

(3) Topsy Campground – The proposed boundary change would exclude Topsy Campground, which is covered by the current license. Interior states that Topsy Campground should remain within the project boundary because it is the only developed and staffed camping facility on the J.C. Boyle reservoir and that the demand for camping there is high on most weekends during the summer, despite the limited number of campsites, group sites, and improved day-use sites.

Additionally, Oregon Parks & Rec recommends that PacifiCorp share with the Bureau of Land Management in the operation and maintenance of Topsy Grade Road, which provides primary access to the river, allowing for whitewater shuttles between Frain Ranch and Stateline Take-out, as well as access to Fishing Access Sites 1 through 6.

Our Analysis

Project boundaries must "enclose only those lands necessary for operation and maintenance of the project and for other project purposes, such as recreation, shoreline control, or protection of the environmental resources."[151] Thus, our consideration of PacifiCorp's proposed project boundary, as well as the project boundary recommendations of others, turns on whether the facilities are used for project purposes or are needed to protect project-related environmental resources. Areas that require long-term maintenance by the licensee fall under the latter definition. Areas that are not required for project purposes or do not require long-term maintenance by the licensee to protect project-related environmental resources may be removed from the project boundary. The effects of such removal would depend on the level of maintenance provided by the owner.

With respect to Interior's comment that Powerhouse Road should be included in the project boundary, we reviewed the record and find that the segment of the road that PacifiCorp includes in the proposed project boundary (that is, from the road network near the dam, past the powerhouse, to just past the Spring Island boater access site) serves project purposes, including serving as a turn-around point for PacifiCorp vehicles. The remainder of the road, south from Spring Island boater access, does not appear

[150] The road also provides access to the Bureau of Land Management's Klamath River Campground.

[151] 18 CFR §4.41(h)(2).

to serve any project purpose, in that it does not provide access to project recreation facilities or project transmission lines. The Powerhouse Road Bridge across the Klamath River washed out a number of years ago, thus precluding use of this road for any project purposes.

As pointed out by Interior in its comments, the upslope area of the J.C. Boyle bypassed reach between the power canal and emergency spillway and the river have been and are likely to continue to be affected by the project, particularly related to spillway overflows and any canal damage. This area is likely to require PacifiCorp's long-term commitment to repair project-related environmental damages and prevent their recurrence.

With respect to Topsy Campground, we agree with Interior's comment that it serves as the primary recreational facility on J.C. Boyle reservoir, and was included within the project boundary in the original license. There is no information on the record to indicate that conditions have changed that would suggest the area should be removed from the project boundary (see section 3.3.6.2.1, *Recreation Resource Management*).

In support of its recommendation that PacifiCorp share operation and maintenance responsibilities for Topsy Grade Road, Oregon Parks & Rec states that the road was built to facilitate construction of the J.C. Boyle powerhouse. In its response to comments, PacifiCorp points out that Topsy Grade Road actually is a historic stage road that predates the project. In our review, we conclude that part, but not all, of Topsy Grade Road serves project purposes. The segment of Topsy Grade Road that serves project purposes includes the section that accesses Topsy Campground and the proposed Boyle Bluffs recreation area and serves as alternative access to the Red Barn and J.C. Boyle dam.

In our analysis, we also considered other areas, particularly access roads that might be appropriately included within the project boundary. These include the access road between Ager-Beswick Road and the Stateline Take-out, as well as the access road through Sportsman's Park to the proposed upper J.C. Boyle reservoir boater access. Each of these road segments passes through land owned or managed by other entities, but provides sole access to both of these proposed project recreation sites. If the public is not afforded access to the entire road segment, it would be impossible to gain overland access to both of these recreational facilities. The primary function of both recreational sites would be to accommodate recreational boater access. Consequently, unless the entire road segments that provide for this access are included in the project boundary, the Commission could not assure that the public would be able to use either facility.

3.3.7.2.4 Aesthetic Resources

Project facilities and operations can directly affect the aesthetic character of the project area in several ways. Power generating and substation facilities, transmission lines, and the hardscape elements of recreational facilities often create contrasts with the natural landscape and can dominate the views in local areas. Operations that affect the flow in downstream river reaches can either enhance or detract from the attractiveness of the river, depending on the volume of water flowing and the characteristics of the riverscape. Reservoirs, too, can either add to or detract from the aesthetic appeal of an area, with high pool conditions generally more appealing than low pool conditions.

PacifiCorp proposes to reduce the visibility of several project facilities, thereby reducing the contrast with the surrounding area to comply with the Bureau of Land Management's VRM classes and Siskiyou County's aesthetic policies. The proposed aesthetic measures are included in the draft RRMP and include vegetative screening as well as repainting or recoating facilities. The screening component would be coordinated with PacifiCorp's proposed vegetation resource management plan, and would use native vegetation, including tall shrubs and trees. The repainting or recoating component would include consultation on color choices for the facilities with the Bureau of Land Management. PacifiCorp proposes the following improvements:

- at J.C. Boyle dam, painting the Red Barn and adding vegetative screening;
- at the J.C. Boyle powerhouse, repainting or recoating the powerhouse, penstocks, and surge tank, and screening those facilities and the switching station; and
- at Iron Gate dam, repainting or recoating the penstock.

PacifiCorp proposes to complete photo-simulations of the facilities by the first anniversary of the new license, but does not propose to repaint or recoat facilities until the next painting interval for that facility (although not later than year 15 of a new license term). The photo-simulations would be used in consultation with the Bureau of Land Management to identify color choices that would minimize the visual contrast of the project facilities with the surrounding natural landscape. PacifiCorp proposes to make the final color choices based on the results of the consultation with the Bureau of Land Management, as well as the availability and cost of appropriately colored industrial paints or coatings.

The Bureau of Land Management specifies that PacifiCorp include in its RRMP a visual resource management plan that includes provisions and guidelines for managing visual resources on Bureau of Land Management lands from the headwaters of J.C. Boyle reservoir to Iron Gate reservoir. The Bureau of Land Management specifies that the plan describe how the design, maintenance, and construction of project facilities would maintain or preserve visual resource values consistent with the Bureau of Land Management's VRM objectives and guidelines. The Bureau of Land Management provides the following examples of the types of measures that could be used to meet VRM objectives for the project:

- for the bypass canal and other concrete structures, apply acid/stain agent to reduce contrasts in existing structures, add earthtone coloring agents in the concrete mix for new structures, and use vegetative screening or landscaping;
- for the switch yards, power houses, buildings, penstocks, power line structures and other metal structures, apply paint/stain in earthtone colors to reduce contrast and use vegetative screening or landscaping;
- for power lines, replace conductors with non-reflective materials at such time as reflectors would otherwise be replaced;
- for project recreation facilities, including campgrounds and day-use sites, reduce color and form contrast by vegetative or structural screening of all existing and newly constructed facilities, and use vegetation planning to reduce erosion and improve aesthetics; and
- for the J.C. Boyle powerhouse and canal access roads, project roads, other landform alterations, and talus slopes and cutbanks, reduce color and form contrast by establishing vegetation, and use soil tackifiers and bio-stimulants if needed to facilitate revegetation.

PacifiCorp's alternative to this Bureau of Land Management condition modifies the condition to limit the scope to Bureau of Land Management reservation lands within the project boundary, rather than lands from the headwaters of J.C. Boyle reservoir to Iron Gate reservoir, and would restrict PacifiCorp's responsibilities for managing visual resources associated with roads to only those roads for which the licensee is solely or jointly responsible, as determined by the Commission.

The Forest Service makes an instream flow recommendation for the river downstream of Iron Gate dam for salmonid habitat (see section 3.3.3.2.1, *Instream Flows*), and makes the same recommendation for aesthetic purposes.

Our Analysis

PacifiCorp's proposal to improve the appearance of several project features and to reduce their contrast with the surrounding area would clearly improve the aesthetic environment in the vicinity of J.C.

Boyle dam, the J.C. Boyle bypassed reach, and Iron Gate dam. The proposed use of photo-simulations in consultation with the Bureau of Land Management would help ensure that the color selected for application in each case would be most appropriate to reducing the visual contrast of that facility.

PacifiCorp's proposed improvements would address two of the five project features that are currently not consistent with their Class II VRM classification–the J.C. Boyle powerhouse and penstocks–and would leave three not addressed–the J.C. Boyle dam, bypass canal, and transmission line. It would also not address the project facilities that are currently not consistent with their Class III VRM classification–West Side powerhouse, Copco No. 1 dam and powerhouse, Copco No. 2 powerhouse and substation, Fall Creek powerhouse, and Iron Gate Hatchery and fish ladder.

Our review indicates that some of the facilities not addressed by PacifiCorp's proposal would not be aesthetically displeasing if left as they are, although they would not meet the Bureau of Land Management VRM class objectives. For example, J.C. Boyle dam and bypass canal, while they attract the attention of the viewer, present horizontal forms that fit the scale of the background hillsides and do not dominate the view. It does not appear that applying acid/stain agent to the dam and bypass canal, as recommended by the Bureau of Land Management, would achieve a substantial improvement. Once the J.C. Boyle power house, penstocks, surge tank, and switching station are screened with vegetation and/or repainted or recoated, as PacifiCorp proposes, the transmission line would not be as noticeable to the viewer. The Copco No. 1 dam and powerhouse, while dominant in the view of someone nearby, are placed such that they are not seen by the average visitor to the area. Iron Gate Hatchery and fish ladder are less of an aesthetic issue because they are much less prominent when seen from a slight distance. However, the remaining facilities that are currently not consistent with their VRM classification, the Fall Creek powerhouse and Copco No. 2 powerhouse and substation, are very visible to the public. Without the type of vegetative screening and repainting or recoating proposed by PacifiCorp for other facilities, their aesthetic appearance would remain objectionable to some viewers. However, in its comments on the draft EIS, PacifiCorp notes that vegetative screening and repainting or recoating of the Fall Creek and Copco No. 2 facilities could cause adverse effects on these historic properties, and such measures would require consultation with the California SHPO.

The Bureau of Land Management's specification that the RRMP include a visual resource management plan that includes provisions and guidelines for managing visual resources on Bureau of Land Management lands would ensure that expectations regarding how visual quality objectives would be achieved are clearly understood by PacifiCorp and appropriate agencies. However, such a plan would apply only to project-related facilities, which are all within the project boundary, or as noted by PacifiCorp in its alternative condition for managing visual resources, associated with those roads for which PacifiCorp is solely or jointly responsible, as determined by the Commission.

In support of its flow recommendation for the river downstream of Iron Gate dam, the Forest Service states that the recommended flows would be representative of natural scenic variability over time. While this statement is no doubt true, we note that other flows, such as those specified in the BiOp and discussed in section 3.3.3.2, *Instream Flows*, also would provide aesthetic variability throughout the year.

3.3.7.2.5 Development Decommissioning and Dam Removal

If any of the project developments are decommissioned, the decommissioning plans would address the topic of post-decommissioning land use, including the disposition of project-related land uses such as recreational facilities. We cannot speculate at this time on what that disposition might be. Any land owned by PacifiCorp could be sold to other parties. In a study of 30 dam removal sites in Wisconsin, Orr and Stanley (2006) found that half of the formerly inundated lands supported a wide variety of human activities, including baseball diamonds, bike trails, picnic areas, playgrounds, hay fields, row crops, and grazing. Of the 15 remaining vegetated sites, 13 were not actively managed and 2 were planted with native vegetation as part of ongoing restoration efforts. The authors suggest that the number

of developed sites indicates that former reservoirs are often viewed as available land and the change of perception of the area sequentially as a lake, mud flat, and finally, dry property may be fairly rapid. However, when there are sufficient issues regarding how land formerly associated with a development would be managed after the Commission relinquishes jurisdiction, a decommissioning plan is beneficial in establishing an orderly transition. A decommissioning plan is not intended to include measures that extend beyond the relinquishment of Commission jurisdiction. At the Keno development, unlike other project developments, if the Commission determines that this development no longer serves project purposes, it would no longer be under the Commission's jurisdiction, effective at the time the Commission makes such a determination. Consequently, the Commission would not have the authority to require the development and implementation of a decommissioning plan at the Keno development.

With respect to aesthetic resource values, in section 4.7, *Conceptual Costs of Project Dam Removal*, we describe conceptually what would be involved in decommissioning each of the developments if the dams and/or other facilities were removed. The conceptual plans, specific to each development, generally include removal of most facilities, drainage of the reservoirs, and re-grading and re-vegetation of the sites in proximity to the dams. A common concern of landowners near dams being considered for removal is that the area exposed by a drawdown will persist as an open mudflat. A study by Orr and Stanley (2006) demonstrated that vegetation colonized newly exposed sediment in as little as a month from dam removal, and high vegetative cover persisted in the years following dam removal. Some areas, such as the downslope channel associated with the J.C. Boyle canal emergency spillway and the tailrace area, would be backfilled and stabilized near the Klamath River. Where transmission line rights-of-way are no longer needed, they would be restored to natural conditions. These provisions, which would be spelled out in any decommissioning plans, would help ensure that the areas would develop a more natural appearance as vegetation matures over time.

3.3.7.3 Unavoidable Adverse Effects

None.

3.3.8 Socioeconomic Resources

3.3.8.1 Affected Environment

The six-county study area for PacifiCorp's socioeconomic analysis includes Klamath, Jackson, and Curry counties in Oregon and Siskiyou, Humboldt, and Del Norte counties in California (figure 3-136). Project facilities are in Klamath and Siskiyou counties; the other counties are included because their economies, local services, and human resources could be affected by incremental changes in project investments and operations. PacifiCorp divided the study area into two broad subregions because of differences in how the Klamath River is used upstream and downstream of Iron Gate dam. The upstream subregion includes Klamath, Jackson, and Siskiyou counties and the downstream subregion includes Curry, Humboldt, and Del Norte counties. PacifiCorp collected socioeconomic data for two additional subregions within the same six-county area. These two subregions consist of two corridors that both extend from Link River dam down the Klamath River to the Pacific Ocean, and along the coast terminating at the boundaries of the Klamath Management Zone (KMZ)(Humbug Mountain, Oregon, and Horse Mountain/Shelter Cove, California) (see figure 3-136). The first corridor, which we refer to as the 5-mile corridor, extends 5 miles on each side of the river and 5 miles inland along the coast. The 5-mile corridor area also includes the communities of Yreka and Dorris, California, which are slightly beyond 5 miles from the river but were considered by PacifiCorp's study team to have a strong connection to the river. The second corridor, the 50-mile corridor, extends up to 50 miles on each side of the river and 50 miles inland along the coast. PacifiCorp's study reports information for the region and subregions at the geographic scale it deemed most pertinent, given data limitations.

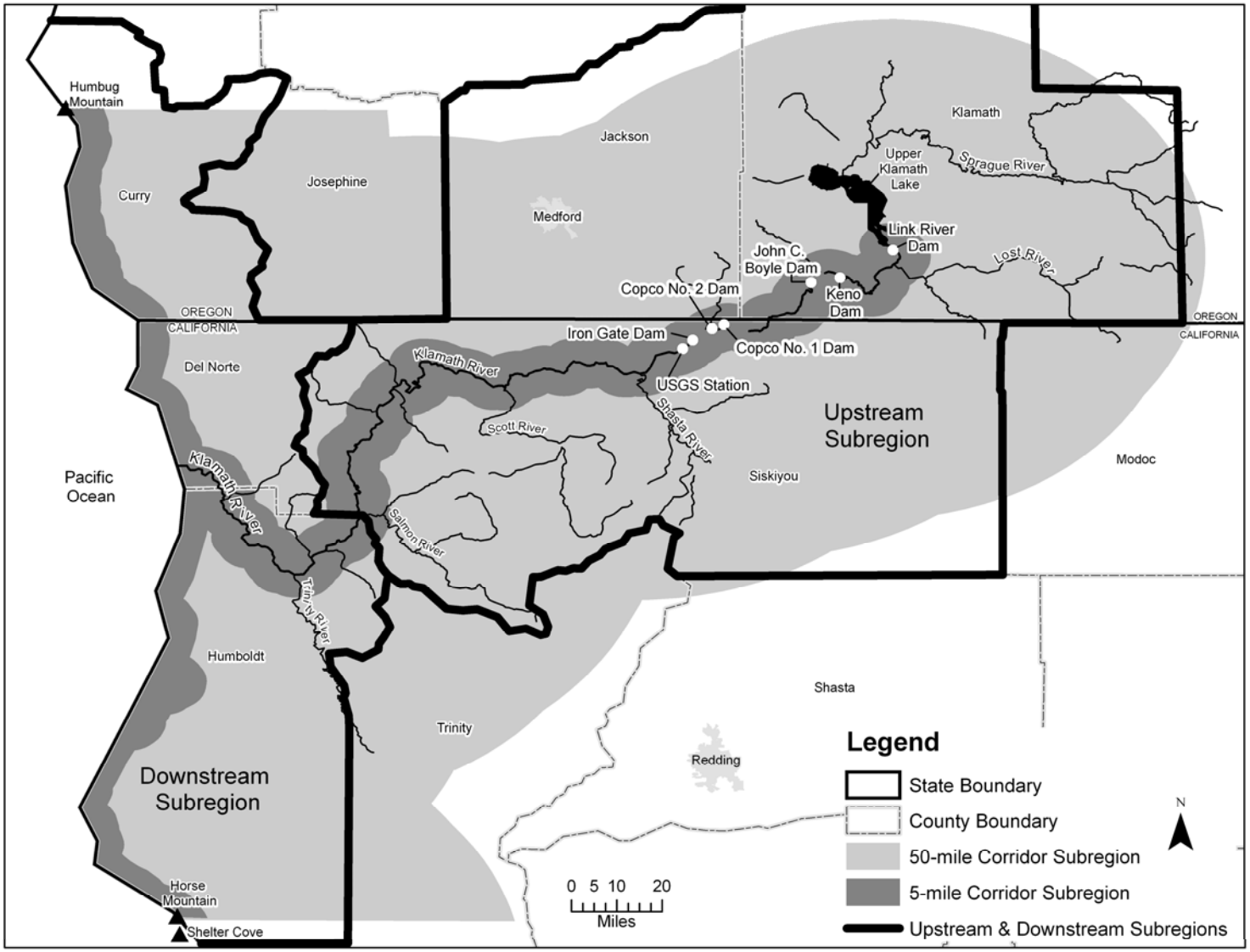

Figure 3-136. Socioeconomic study region and subregions. (Source: Staff)

Although not addressed specifically in PacifiCorp's studies, there are six Native American tribes within the six-county study area.

- The Klamath Tribes' former reservation lands were located northeast of Klamath Lake near Chiloquin, Klamath County, Oregon. The Klamath Termination Act (P.L. 587) terminated federal recognition of the Tribes, and at the same time terminated the reservation. The Tribes regained federal recognition in 1986, but there is no longer a Klamath reservation (Klamath Tribes, 2006).
- The Quartz Valley Indian Community includes a federal reservation of Klamath, Karuk, and Shasta Indians in northwestern California near the community of Fort Jones, Siskiyou County, California. The total reservation area today is about 174 acres (San Diego State University, 2006a).
- The Karuk Tribe, which is today one of the largest tribes in California, has a small land base, with most of the Karuk Tribe living in Humboldt and Siskiyou counties, California, and in southern Oregon (San Diego State University, 2007).
- The Yurok Indian Reservation encompasses 56,585 acres located 1 mile on either side of the Klamath River from the mouth at the Pacific Ocean upstream 22 miles, extending through Del Norte and Humboldt counties, California (San Diego State University, 2006b).
- The 85,446-acre Hoopa Valley Indian Reservation is located along the Trinity River in northeast Humboldt County, California (San Diego State University, 2007).
- The Resighini Rancheria is a 228-acre federal reservation of Karuk Indians in Del Norte County, California. The reservation spans the mouth of the Klamath River (San Diego State University, 2006a).

Unless otherwise indicated, the following description of the socioeconomic environment is taken from PacifiCorp's license application, exhibit E.9, *Socioeconomic Resources* (PacifiCorp, 2004a) and the associated Final Technical Report (PacifiCorp, 2004g).

3.3.8.1.1 Demographic Characteristics

Population, Race, and Ethnicity

The total population within the six-county study area in 2000 was 464,507 people, of whom 289,345 lived in the upstream subregion and 175,162 lived in the downstream subregion. The 5-mile corridor through the upstream counties represents about 20 percent of the upstream subregion population, while the 5-mile corridor through the downstream counties captures about 80 percent of the downstream counties' population. PacifiCorp concludes that the county-level data for the downstream subregion is likely to be adequately representative of the 5-mile corridor population in the downstream subregion as well, while the county-level upstream subregion population characteristics may not be representative of the 20 percent of the population living in the 5-mile corridor in the upstream subregion.

The county populations in the study area have exhibited relatively low annual growth rates since 1970, in line with the growth rates of the states as a whole. The average annual growth rate from 1970 to 2000 was 1.6 percent in the upstream region, 1.1 percent in the downstream region, 1.8 percent in Oregon, and 1.0 percent in California. Average annual growth rates for 2000 to 2040 are projected to be lower across the board: 0.9 percent in the upstream region, 0.7 percent in the downstream region, 1.0 percent in Oregon, and 0.7 percent in California.

The largest racial group in the study area is white, representing more than three-fourths of the population. The American Indian population constitutes the second largest racial group in all but Jackson County, where the second largest racial group consists of individuals who characterized themselves in the

2000 census as being of "Two or More Races." Within the 5-mile corridor, the community of Klamath, California, census designated place (CDP) had the highest concentration of minority (nonwhite) population in 2000. About 46 percent of the population of the Klamath CDP is nonwhite, with almost three-fourths of the minority population being American Indian. Excepting Klamath CDP, the percentage of minority population ranges from 6.5 percent in Ferndale, California, to 22.6 percent in Crescent City, California. Table 3-105 shows the race and ethnic distribution of the population in the communities within the 5-mile corridor.

In its comments on the draft EIS, the Yurok Tribe cites 2000 census data indicating that 75 percent of the population living within the Yurok and Hoopa Valley Indian Reservations in the downstream subregion are "American Indian alone or in combination with one or more other races". The Yurok Tribe also cites census data to indicate that the two reservations are growing at a much faster rate than the roughly 1 to 2 percent average annual growth rate reported above for the regions as a whole. Table 3-106 summarizes reservation demographic data from the 2000 census (Bureau of the Census, 2000), which shows American Indians ranging from 28.9 percent of the Quartz Valley Community population to 100 percent on the Resighini Rancheria population.

Table 3-105. Race and ethnic distribution by county and community within the 5-mile corridor, 2000. (Source: PacifiCorp, 2004a)

	Total Population (people)	White (%)	American Indian and Alaskan Native (%)	Two or More Races (%)	Other Races[a] (%)	Hispanic[b] (%)
Upstream Subregion						
Klamath County, OR	50,970	88.2	3.6	3.5	4.7	7.2
Midland	1,301	95.0	0.7	3.2	1.2	8.5
Keno	1,011	93.8	0.7	4.8	0.7	2.4
Klamath Falls City	19,335	85.1	5.0	3.4	6.7	8.8
Jackson County, OR	785	92.6	3.4	3.9	0.0	0.5
Siskiyou County, CA	21,725	86.2	5.5	3.7	4.5	6.2
Clear Creek/Fort Goff/Hamburg	525	78.3	15.4	4.0	2.3	2.1
Copco	1,648	89.3	5.0	3.9	1.8	4.2
Dorris City	902	77.7	8.1	3.7	10.6	19.5
Gottsville/Henley/Klamathon	743	86.4	6.6	4.7	2.2	4.3
Happy Camp	667	68.8	24.9	5.7	0.6	3.9
Hornbrook CDP	314	88.5	6.4	3.5	1.6	6.7
Horse Creek	1,749	91.6	2.1	4.5	1.9	7.0
Klamath River/Nolton/Seiad Valley	990	75.2	15.5	7.1	2.3	3.8
Montague City	1,525	91.3	3.7	3.2	1.7	3.9
Somes Bar	891	82.6	10.9	6.1	0.4	2.5
Yreka City	7,442	86.1	4.1	3.1	6.8	5.4
Downstream Subregion						
Curry County, OR	18,082	93.3	2.4	2.2	2.0	3.4
Brookings City	5,363	91.1	2.3	2.7	3.8	4.5
Gold Beach City	1,864	95.9	1.7	1.6	0.9	2.2

	Total Population (people)	White (%)	American Indian and Alaskan Native (%)	Two or More Races (%)	Other Races[a] (%)	Hispanic[b] (%)
Del Norte County, CA	26,583	78.8	5.9	4.6	10.7	13.7
Bertsch-Oceanview CDP	2,097	82.7	7.4	3.9	6.0	7.2
Crescent City	3,888	77.4	6.2	5.6	10.8	10.8
Crescent City North CDP	4,069	79.2	3.4	9.6	7.6	9.0
Klamath CDP	653	54.2	39.4	4.9	1.5	4.9
Klamath Glen/Requa	1,126	59.7	28.7	6.5	5.2	8.5
Humboldt County, CA	101,152	84.9	6.1	5.0	2.1	5.7
Arcata City	16,714	83.8	3.0	5.9	7.3	7.1
Bayview CDP	2,355	82.4	5.0	4.6	7.8	9.3
Cutten CDP	3,096	88.6	6.4	3.8	1.2	6.5
Eureka City	25,929	82.9	4.2	6.5	6.6	7.2
Ferndale City,	1,421	93.5	1.0	3.9	1.6	4.2
Humboldt Hill CDP	3,252	85.0	2.2	5.0	7.9	7.8
Johnsons/Pecwan/Kanick/ Martin's Ferry/Surgone/ Waseck/Weitchpec	465	19.6	69.2	8.8	2.4	2.4
McKinleyville CDP	13,601	88.5	3.5	5.2	2.7	4.4
Myrtletown CDP	4,375	87.6	1.6	2.4	8.3	3.9
Orleans	601	64.1	23.6	7.5	4.8	3.5
Pine Hills CDP	3,096	93.2	2.3	3.4	1.2	2.8
Trinidad City	331	88.8	1.2	4.6	5.1	4.8
Westhaven-Moonstone CDP	1,046	90.0	3.0	4.7	2.4	4.5

[a] Other races includes Black or African American, Asian, Native Hawaiian and Other Pacific Islander, and "Some Other Race."

[b] Hispanics may be of any race.

[c] These communities are part of the same census block group; data are not available separately for each community in the group.

Table 3-106. Population and percent of residents identified as American Indian alone or in combination with one or more other races by reservation within the six-county study area. (Source: Bureau of the Census, 2000)

	Total Population 2000 (people)	American Indian and Alaskan Native (%)
Quartz Valley Indian Community	126	28.9
Karuk Reservation	333	74.5
Yurok Reservation	1,103	48.8
Hoopa Valley Indian Reservation	2,633	86.7
Resighini Rancheria	36	100.0

Employment

Each county in the study region has experienced net job growth between 1980 and 1999. With the exception of Jackson County, Oregon, however, the average annual growth rates for the study region counties have been lower than their respective state growth rates. From 1990 to 1999, employment grew at an average annual rate of 2.7 percent in Oregon, while growth in the study region counties was 1.9 percent in Curry County, 1.6 percent in Klamath County, and 3.2 percent in Jackson County. During the same period, employment grew at an average annual rate of 1.3 percent in California, while growth in the study region counties was 0.9 percent in Del Norte County, 1.2 percent in Humboldt County, and 1.1 percent in Siskiyou County.

Throughout the study region, services, retail trade, and government are the three industries with the greatest percentage of total county employment. Service employment ranges from 26 percent of employment in Curry County to 31 percent in Humboldt and Jackson counties. Retail trade employment ranges from 17 percent in Del Norte and Klamath counties to 22 percent in Curry and Jackson counties, while government employment ranges from 11 percent in Jackson County to 28 percent in Del Norte County. Agriculture varies in importance in terms of employment, with total employment in agriculture (farm employment as well as employment in agricultural services) comprising a substantially larger portion of all jobs in Siskiyou (8.0 percent) and Klamath (7.2 percent) counties than in Del Norte (4.9 percent), Curry (3.8 percent), Humboldt (3.4 percent), and Jackson (3.2 percent) counties. Employment in the fishing, hunting, and trapping sector is low but large enough to be reported in Del Norte (1.1 percent), Curry (0.9 percent), and Humboldt (0.1 percent) counties. Employment data for the fishing, hunting, and trapping sector are not reported by the census for the other three counties to avoid disclosing confidential information.

Employment related to recreation and tourism is not separately reported in the census, but is reported as part of the services and retail trade sectors. Because that sector is so large, the extent of recreation- and tourism-related employment cannot be discerned from the census data.

Historically, communities along the coast were dependent on ocean commercial and recreational sportfishing. Employment in commercial fishing is included in the estimates for the fishing, hunting, and trapping sector noted above. Along with commercial fishing, the coastal communities were also dependent on the packing and processing plants that prepared the fish for market. However, most of the packing and processing plants, whose employment used to be reported as part of the manufacturing sector, have closed.

For the communities within the 5-mile corridor, the services and retail trade sectors account for about two-thirds of employment. Comparing the 1990 and 2000 employment data shows a decline in employment in the agriculture, forestry, fishing, and hunting category for several communities, and an increase in a few communities (table 3-107).

Additionally, most of the communities in the 5-mile corridor experienced a decline in manufacturing employment from 1990 to 2000. The most substantial declines occurred in Clear Creek/Fort Goff/Hamburg, California (from 21.4 to 1.8 percent), Happy Camp, California (from 30.1 to 1.1 percent), and Somes Bar, California (from 22.8 to 1.8 percent).

While the period from 1990 to 2000 was characterized by the general loss of manufacturing jobs in almost all the communities in the 5-mile corridor, those losses were offset in some communities by gains in the agriculture, forestry, fishing, and hunting sector as well as the services sector. The communities of Clear Creek/Fort Goff/Hamburg, Klamath CDP, and Klamath River/Nolton/Seiad Valley gained jobs in the agriculture, forestry, fishing, and hunting sector, while Klamath CDP, Happy Camp, and Gottsville/Henley/Klamathon gained a substantial number of jobs in the services sector.

Table 3-107. Distribution of employment (percent) in agriculture, forestry, fishing, and hunting by community, 1990 and 2000. (Source: PacifiCorp, 2004a)

Community	1990 Employment	2000 Employment
Decline in Employment		
Dorris, CA	20.6	14.3
Gottsville/Henley/Klamathon, CA	19.2	11.5
Happy Camp, CA	14.8	8.7
Keno, OR	11.6	6.0
Westhaven-Moonstone CDP, CA	15.3	0.7
Gold Beach, OR	10.1	4.7
Increase in Employment		
Clear Creek/Fort Goff/Hamburg, CA	10.0	25.0
Klamath CDP, CA	5.5	8.9

Between 1992 and 2001, unemployment rates declined in all of the counties, but were generally above the averages for their respective states throughout the period. Siskiyou and Del Norte counties experienced the most substantial decreases in unemployment, but their unemployment rates remained well above 8 percent in 2001. Excepting Ferndale, Myrtletown, and Pile Hills, unemployment rates are generally higher in the communities in the 5-mile corridor than in their respective counties. The county unemployment rates in 2001 were higher than the state averages for California and Oregon, both of which had statewide unemployment rates of 4.9 percent in 2000. Unemployment rates have generally risen since 2001. In 2004, when the seasonally unadjusted employment rate was 7.4 percent in Oregon and 6.2 percent in California, the unemployment rates in the study region ranged from 6.5 in Humboldt County, California, to 9.5 percent in Klamath County, Oregon (Bureau of Labor Statistics, 2006).

In its comments on the draft EIS, the Yurok Tribe cites Bureau of Indian Affairs data indicating the unemployment rate was as high as 75 percent for Yurok and 40 percent for Hoopa Valley tribal members in 2001, compared to unemployment rates in Humboldt, Del Norte, and Curry counties of 6, 8.1, and 6.9 percent respectively during the same year.

Income

Average per capita personal income in 1999 in each study region county was lower than the respective state average. Average per capita personal income in Oregon was $26,958, while it was $24,004 in Jackson County (89 percent of the state average), $22,726 in Curry County (84 percent), and $20,886 in Klamath County (77 percent). In California, where average per capita income was $29,858, the comparable figures were $22,871 in Humboldt County (77 percent of the state average), $21,092 in Siskiyou County (71 percent), and $17,722 in Del Norte County (59 percent).

In general, the communities within the 5-mile corridor had lower per capita incomes than those reported at the county or state level. The only exception is the city of Trinidad, which had a 1999 per capita income of $28,050, equaling 123 percent of the Humboldt County average and 94 percent of the California state average. In other communities, per capita incomes ranged from a high of $22,653 in Somes Bar, California, to a low of $6,894 in the aggregate representing Johnsons, Peewan, Kanick, Martin's Ferry, Surgone, Waseck, and Weitchpe, California.

The per capita income of the American Indian population in each of the six counties in the study region is about 50 percent lower than that observed for the entire population in each of the counties. Additionally, with the exception of Curry County, the counties in the study region have a substantially

higher percentage of low-income population among the American Indian population compared to the overall population. In 2000, more than two-thirds of the American Indian population in Ferndale and Myrtletown and more than half of the American Indian population in Klamath Falls and Yreka were low income. Table 3-108 summarizes the percentage of low income persons in the general population and in the American Indian population for the communities in the 5-mile corridor. The table also indicates the percentage of substandard housing by community, another measure of low income status. Table 3-109 provides additional information concerning the incidence of poverty on the Indian reservations in the six-county study area.

Table 3-108. Distribution of low incomes and substandard housing (percent) by community in the 5-mile corridor, 2000. (Source: PacifiCorp, 2004a)

	Low Income Distribution in Total Population		Low Income Distribution in American Indian Population		Substandard Housing
	Persons	%	Persons	%	%
Upstream Subregion					
Klamath County, OR	8,563	16.8	733	39.9	3.0
Midland	53	4.1	0	0.0	0.0
Keno	97	9.6	0	0.0	4.8
Klamath Falls City	4,234	21.9	500	52.2	2.6
Jackson County, OR	98	12.5	5	19.8	18.1
Siskiyou County, CA	4,041	18.6	379	31.7	5.4
Clear Creek/Fort Goff/Hamburg	112	21.3	36	44.4	24.6
Copco	201	12.2	51	61.8	5.3
Dorris City	172	19.1	15	20.5	2.4
Gottsville/Henley/Klamathon	123	16.5	22	43.9	9.1
Happy Camp	168	25.2	73	43.9	9.0
Hornbrook CDP	67	21.3	5	25.0	9.5
Horse Creek	297	17.0	6	16.7	4.8
Klamath River/ Nolton/Seiad Valley	238	24.0	105	68.5	9.4
Montague City	369	24.2	10	17.5	0.2
Somes Bar	122	13.7	36	37.1	24.8
Yreka City	1,578	21.2	159	52.2	0.5
Downstream Subregion					
Curry County, OR	2,206	12.2	64	14.6	3.1
Brookings City	617	11.5	15	12.0	1.2
Gold Beach City	231	12.4	0	0.0	2.2
Del Norte County, CA	5,370	20.2	402	25.8	1.2
Bertsch-Oceanview CDP	380	18.1	57	36.6	0.0
Crescent City	1,345	34.6	96	39.9	0.0
Crescent City North CDP	696	17.1	23	16.5	1.0
Klamath CDP	99	15.2	36	14.0	6.4
Klamath Glen/Requa	163	14.5	75	23.2	23.2

	Low Income Distribution in Total Population		Low Income Distribution in American Indian Population		Substandard Housing
	Persons	%	Persons	%	%
Humboldt County, CA	19,725	19.5	1,926	31.0	2.9
Arcata City	5,382	32.2	195	38.9	0.5
Bayview CDP	544	23.1	50	42.4	1.0
Cutten CDP	418	13.5	14	7.0	1.6
Eureka City	6,145	23.7	412	37.9	1.7
Ferndale City	101	7.1	10	70.0	2.0
Humboldt Hill CDP	374	11.5	15	20.6	1.7
Johnsons/Pecwan/Kanick/ Martin's Ferry/ Surgone/ Waseck/ Weitchpec	270	58.0	NA	NA	50.2
McKinleyville CDP	2,027	14.9	57	11.8	0.8
Myrtletown CDP	582	13.3	46	66.7	0.2
Orleans	123	20.5	86	60.6	43.0
Pine Hills CDP	297	9.6	7	10.0	1.7
Trinidad City	29	8.8	0	0.0	4.4
Westhaven-Moonstone CDP	147	14.1	15	48.4	0.8

NA = not available

Table 3-109. Income and poverty on the Indian reservations in the six-county study area. (Source: Bureau of the Census, 2000)

		Percent of Families Below Poverty Level in 1999		
	Median Household Income	All Families	Families with Children under 18 Years of Age	Families with Children under 5 Years of Age
Quartz Valley Indian Community	$29,375	37.1	68.4	0.0
Karuk Reservation	$18,000	60.0	62.1	73.0
Yurok Reservation	$20,592	26.8	36.3	60.0
Hoopa Valley Indian Reservation	$23,384	29.0	36.9	40.5
Resighini Rancheria	$41,250	0.0	0.0	0.0

As described by the Yurok Tribe in its comments on the draft EIS, there are additional demographic characteristics that differentiate the Yurok Tribe and other tribes from the non-Indian communities in the study area, particularly related to their relationship with the Klamath River and its resources. In 2006 the Yurok Tribe circulated a survey to determine the impact of the deteriorating health of the Klamath River on the health and wellbeing of tribal members. The Yurok Tribe presents some of the results of the *Healthy River, Healthy People, Traditional Foods Survey* in its comments on the draft EIS. Although the survey had a low response rate (under 13 percent), the respondents included both those living within the ancestral territory[152] (56 percent of respondents) and those living elsewhere (44 percent of respondents), and together with other data compiled by the Yurok Tribe provides the best documentation to date concerning the status of the tribal members and their relationship to the river. Among the findings presented by the Yurok Tribe are the following:

[152]The Yurok Tribe describes its ancestral territory as including parts of Humboldt, Del Norte, and Curry counties.

- 31 percent of the respondents living in the ancestral territory in Humboldt, Del Norte, and Curry counties earned less than $10,000 per year, compared to an average of 13 percent to 16 percent of all households in the three counties.
- Incomes reported by respondents living elsewhere were significantly higher than those living within the ancestral territory, with more than 25 percent of those living elsewhere reporting incomes greater than $60,000 per year, compared to less than 10 percent of those living within the ancestral territories.
- Harrison et al., (2002) identify families and households as "food insecure" if their incomes are less than 200 percent of the federal poverty level. Their study found that this level of income applied to 32 percent of Del Norte and Humboldt county residents in 2002. In contrast, the Yurok's survey found this level of income applied to 80 percent of the survey respondents residing within the Yurok ancestral territory in 2006, or almost three times that found by Harrison et al. in the general population.
- Of the survey respondents, 76 percent of those living in the ancestral territory report receiving food assistance through food stamps or participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC Program) or Commodity Supplemental Foods Program, compared to 24 percent of respondents who live elsewhere.
- Among survey respondents 65 and older, the prevalence of diabetes is significantly greater among those who receive food assistance than those who do not, while the prevalence of obesity, hypertension, and heart disease show no significant differences between the groups.

The Yurok Tribe concludes that the poverty of tribal members and their food insecurity, dependence on food assistance, and prevalence of diabetes are caused by their lack of access to traditional food sources formerly provided by the Klamath River, including fall Chinook and coho salmon in the late summer and fall; steelhead, lamprey, and candle fish during the winter; and spring Chinook salmon, sturgeon, and lamprey during the spring and summer. Similarly, Norgaard (2005) reports that the estimated diabetes rate among the Karuk Tribe is 21 percent, four times higher than the U.S. average, and the estimated rate of heart disease for the Karuk Tribe is 39.6 percent, three times the U.S. average. Norgaard attributes the high rates of these and other health problems, such as hypertension, to the Tribe's loss of its traditional foods, particularly salmon, as wells as other foods from plants, animals, and fungi. Norgaard cites statistics by Hewes (1973) indicating that traditional fish consumption among the Karuk Tribe was 450 pounds per person per year, compared to current estimates of about 5 pounds per person per year in 2003 and less than one-half pound per person in 2004 (Norgaard, 2005).

3.3.8.1.2 Project-related Economic Sectors

The project relates to the local economy in many ways. Most directly, the project provides some employment and income, and PacifiCorp pays local and county taxes related to the project. Recreation, commercial fishing, tribal fishing, and agriculture are other economic sectors related to project operations.

Project Employment, Payroll, and Taxes

Currently, the project employs 19 individuals and has a total annual payroll of about $820,000. During fiscal year 2003-2003, PacifiCorp paid property taxes to the following entities:

- Klamath County: $1.58 million, about 4.5 percent of the county's $35 million in property tax revenue
- City of Klamath Falls: $105,160

- Siskiyou County: $1.1 million, about 18 percent of the county's $6.54 million in property tax revenue

PacifiCorp also pays franchise taxes to the city of Yreka. In 2002, PacifiCorp paid $64,767 in franchise taxes, representing about 1 percent of the city's gross revenue that year.

Recreation

In the upstream subregion, the Klamath River and its reservoirs support a number of recreational pursuits, including whitewater boating (private and commercial), sport fishing (private and commercial), camping, and waterskiing. Based on surveys prepared in connection with project relicensing, PacifiCorp reports that, in 2002, non-local visitors to the upstream subregion spent an estimated $840,900 to $909,600 in the 5-mile corridor, and between $1,648,000 and $1,716,700 in the 50-mile corridor (EDAW, Inc., 2003, as cited in PacifiCorp, 2004a). Table 3-110 summarizes total and non-local visitor expenditures by participants in various recreational activities in 2002.

Table 3-110. Annual recreation use and associated expenditures of total and non-local visitors in the upstream subregion, 2002. (Source: PacifiCorp, 2004a)

Primary Activity	Primary Purpose Recreation Days (User Days)	Expenditure Per Person Per Day ($)	Total Expenditure			
			Local and Non-local Visitors	Non-local Visitors to the Project Area	Non-local Visitors, 5-Mile Corridor	Non-local Visitors, 50-Mile Corridor
Boat Fishing	30,270	$5.12	$154,982	$119,340	$119,340	$136,390
Waterskiing	23,040	$7.81	$179,942	$136,760	$136,760	$167,350
Resting/Relaxing	21,120	$4.06	$85,747	$60,020	$60,020	$69,450
Shoreline Fishing	15,360	$17.02	$261,427	$130,714	$130,714	$209,143
RV Camping	11,520	$7.05	$81,216	$70,660	$70,660	$70,660
Whitewater Boating	5,090	$134.25 - $149.35	$683,333 - $760,191	$55,736 - $63,880	$93,911 - $162,626	$627,597 - $696,311
Other	77,470	$5.54	$429,184	$206,008	$206,008	$339,055
No Primary Activity	7,680	$4.25	$32,640	$23,450	$23,450	$28,350
Total	192,000	$9.94 - $10.34	$1,908,471 - $1,985,329	$802,688 - $810,832	$840,863 - $909,578	$1,647,995 - $1,716,709

In a letter filed with the Commission on November 22, 2005, Momentum River Expeditions provided information related specifically to whitewater boating on the Hells Corner section of the upper Klamath River, located between J.C. Boyle dam and Copco reservoir. According to Momentum River Expeditions:

- Commercial operators handle more than 90 percent of the whitewater boating in this section of the river because of the difficult logistics of the run.
- Twenty-two companies have permits to run this section of the river, many of whom depend directly on this stretch to stay in business.
- An average of 4,000 to 5,000 people from around the United States and the world run this section of the river with outfitters each year.
- Outfitters collect an average of $520,000 in gross revenues annually from trips on this section of the river.

- Each outfitter spends a significant portion of gross revenue locally on fuel, food, labor, marketing, and other expenses.
- Other spending by whitewater rafting guests for lodging, dining, shopping, and other activities is estimated at $3.5 million annually.

Momentum River Expeditions does not cite any sources or the methods used in making the estimates provided in its letter. Its estimate of whitewater boaters (4,000 to 5,000 boaters with commercial outfitters) is similar to the PacifiCorp estimate shown in table 3-110 (5,090 total whitewater boaters), and its estimate of gross outfitter revenue ($520,000) is relatively similar to PacifiCorp's range of total local and non-local whitewater boater expenditures in the region ($683,333 to $760,191). However, its estimate of total whitewater boater expenditures in the region ($3.5 million) is substantially greater than the figures reported in table 3-110 ($1.9 to $2.0 million).

Primary recreation activities in the downstream subregion include whitewater boating, mining, in-river fishing, and ocean sport fishing. In 2002, estimates of expenditures by non-local visitors in the downstream subregion ranged from $6.2 to $6.5 million in the 5-mile corridor and from $7.3 to $7.7 million in the 50-mile corridor (table 3-111). The recreation-related expenditures represent less than 1 percent of personal income for the six-county study region, including the upstream and downstream subregions. However, we note that recreation-related earnings can be substantial for communities within the 5-mile corridor.

Table 3-111. Annual recreation use and associated expenditures of total and non-local visitors in the downstream subregion, 2002. (Source: PacifiCorp, 2004a)

				Total Expenditure		
Primary Activity	**Total User Days**	**Commercial User Days**	**Private User Days**	**Local and Non-local Visitors**	**Non-local Visitors Within 5-Mile Corridor**	**Non-local Visitors Within 50-Mile Corridor**
Whitewater Boating	13,673	9,571	4,102	$1,566,226 - $1,771,319	$371,656 - $576,748	$1,566,226 - $1,771,319
Gold Mining	10,000	0	10,000	$451,350 - $586,350	$451,350 - $586,350	$451,350 - $586,350
Camping	10,526	0	10,526	$543,462	$363,835	$363,835
River Sport Fishing	28,432	204	28,228	$1,486,990	$690,900	$655,070
Ocean Sport Fishing	93,235	7,612	85,623	$4,300,000	$4,300,000	$4,300,000
Total	155,866	17,387	138,479	$8,348,028 - $8,688,121	$6,177,741 - $6,517,833	$7,336,481 - $7,676,574

While Klamath River whitewater boating activity in the downstream subregion has increased over time, in-river fishing has varied from year to year. Angler effort (as measured by angler trips or angler hours) and catch peaked in the mid-1980s at more than 64,000 angler days. Angler effort and catch declined in the late 1980s and early 1990s, recovering somewhat in the late 1990s. The figure noted in table 3-111, 28,432 user days in 2002, indicates a recovery from lower figures in the early 1990s, but is still less than half the mid-1980s peak.

Ocean angler visitor days have followed a similar pattern, reaching their peak of more than 180,000 angler days in 1987 and their low point in 1998 at 32,400 angler days. The 2002 figure of 93,235 user days shown in table 3-111 is slightly more than half the 1987 peak. In 2005, ocean sport fishing was down in part because of management measures taken by the Pacific Fishery Management Council to protect the Klamath River salmon stocks (see section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*). As reported by the Eureka Times-Standard (2005), the 2005 ocean sport

fishery in the KMZ was limited to the period from May 21 through July 4 and again from August 14 to September 11. That allowed sport fishing for just 4 days in July, generally the most active fishing month.

Other information is also available to estimate the value of the recreational ocean salmon fishery to the local area. Table 3-112 shows personal income associated with the recreational ocean fishery in the KMZ since 1976. The pattern is similar to, but less pronounced, than the pattern in the commercial fishery discussed below; that is, personal income related to the fisheries peaked in the late 1980s, fell through the 1990s, recovered somewhat since 2000, but fell dramatically in 2006.

Table 3-112. Estimates of KMZ coastal community personal income (in thousands of real 2005 dollars) from the recreational ocean salmon fishery by port area. (Source: PFMC, 2007a)

Year	Crescent City, CA	Eureka, CA	Fort Bragg, CA[a]	Brookings, OR	Total
1976-1980[b]	1,169	1,385	807	4,845	8,206
1981-1985[b]	1,297	1,349	647	2,671	5,964
1986-1990[b]	2,202	2,311	1,127	2,780	8,420
1991-1995[b]	798	866	1,308	1,044	4,016
1996-2000[b]	372	686	1,335	842	3,235
2001	470	968	2,367	1,190	4,995
2002	210	1,073	2,488	888	4,659
2003	119	813	1,873	681	3,486
2004	175	1,357	2,425	842	4,799
2005	136	871	1,953	570	3,530
2006[c]	76	856	1,533	483	2,948

[a] The Fort Bragg area includes the ports of Fort Bragg, Noyo Harbor, Mendocino, Pt. Arena, and Shelter Cove. Of these ports, only Shelter Cove is included in the KMZ.

[b] Incomes associated with these multiple year periods represent averages over the period.

[c] Preliminary.

Commercial Fishing

Pacific coast salmon compete in the global market, where the competition includes coho and Chinook salmon as well as other salmon species, nonsalmon fish species, other protein sources such as chicken and beef, and farm-raised salmon and trout. The magnitude of west coast Chinook salmon production is comparable to Canadian and Alaskan production, but coho salmon production on the west coast is minor relative to Alaskan production. Currently, salmon products contribute less than 1 percent to the economies of the west coast states. This was not always the case, however, and the contributions of commercial fishing can still be substantial to some coastal communities.

Numerous sources have documented the history of anadromous fish populations and the roles they have played in the economies and cultures of Pacific Coast communities and tribes. PacifiCorp (2004a, g) cites a number of examples, including Lichatowich (1999), Northwest Power Planning Council (NPPC, 1986), PFMC (1999), The Research Group (2000), Spranger and Anderson (1988), and Taylor (1996). Other studies have been submitted related to this licensing proceeding, including reports by Meyer Resources, Inc. (1984) and Norgaard (2005). Historically, and in contrast to the current situation,

the commercial salmon fishery and the associated canneries were substantial components of the west coast economies. The more recent history (1976 to the present) is characterized by downward trends in market prices, poor ocean condition cycles, and adverse habitat alterations (including construction of hydroelectric facilities) for all regions along the west coast of North America. These trends have caused substantial decreases in the amount of income and jobs in economies where salmon and steelhead fishing have historically been important. Coastal communities and tribes have experienced the greatest losses in this regard.

The commercial fishing fleet within the study region (KMZ) boundaries (see figure 3-74) consists of ships that generally fish in waters relatively close to their home ports and land their catch at ports close to the waters where the fish are caught. The KMZ falls under the jurisdiction of the states of California and Oregon, as well as PFMC. PFMC tracks fish landings and fishing effort by port, and generally publishes data for major port areas. The major port areas in the KMZ include Brookings in Oregon and Crescent City, Eureka, and Fort Bragg[153] in California.

Historically, significant Chinook salmon and coho salmon fisheries used the waters now designated as the KMZ. As noted in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management,* the harvest levels of Klamath River fall Chinook salmon in the KMZ were much higher in the mid- to late-1980s (in the tens of thousands of fish) than in the 1990s (in the tens or hundreds of fish) (see table 3-56). The harvest level recovered somewhat from 2001 to 2005, with the catch in the range of 1,400 to 3,900 fish. This pattern in Klamath River fall Chinook salmon harvest levels, coupled with changes (both up and down) in the ex-vessel price of all salmon caught in the KMZ, has been mirrored in the personal income received by commercial fishermen in the KMZ (table 3-113).

Table 3-113. Estimates of KMZ coastal community personal income (in thousands of real 2006 dollars) from the troll ocean salmon fishery by port area. (Source: PFMC, 2007a)

Year	Crescent City, CA	Eureka, CA	Fort Bragg, CA[a]	Brookings, OR	Total
1976–1980[b]	6,147	15,613	15,310	7,623	44,693
1981–1985[b]	3,114	3,757	8,793	2,953	18,617
1986–1990[b]	1,173	2,903	15,445	2,802	22,323
1991–1995[b]	9	138	971	130	1,248
1996–2000[b]	10	164	687	389	1,250
2001	14	279	922	566	1,781
2002	243	466	3,321	717	4,747
2003	196	34	13,491	622	14343
2004	1,731	383	6,623	1,338	10,075
2005	130	391	4,851	1,127	6,499
2006[c]	0	0	2,193	337	2,530

[a] The Fort Bragg area includes the ports of Fort Bragg, Noyo Harbor, Mendocino, Pt. Arena, and Shelter Cove. Of these ports, only Shelter Cove is included in the KMZ.

[b] Incomes associated with these multiple year periods represent averages over the period.

[c] Preliminary.

[153]The Fort Bragg area includes the ports of Fort Bragg, Noyo Harbor, Mendocino, Pt. Arena, and Shelter Cove. Of these ports, only Shelter Cove is included in the KMZ.

Across all four ports, personal income associated with the troll fishery was at its highest point (more than $43 million) from 1976 to 1980 and at its lowest point in the 1990s. In 2001, the figure was back up to almost $2 million, which is still less than 5 percent of the 1976 to 1980 average. The best year since the 1980s was 2003, when personal income related to the salmon troll fishery in the KMZ reached $13.8 million, about one-third of the 1976 to 1980 average.

More recently, as discussed in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management,* management measures taken by the Pacific Fishery Management Council to protect the Klamath salmon stock have reduced the potential income of commercial salmon fishermen. As table 3-113 shows, this is reflected in the lower personal income figures for 2005 and the much lower preliminary figures for 2006.

Tribal Fishery

Citing PFMC (2002a), PacifiCorp reports that recent data are not available on the value of harvest by the Yurok and Hoopa Valley reservation commercial gillnet fisheries on the Klamath River. PacifiCorp cites figures from earlier years to provide insight into the market value of earlier harvests. From 1987 through 1989, commercial tribal harvests of Chinook salmon averaged about 27,500 fish per year. The 1989 harvest, at an average weight of 15.4 pounds per fish, sold for $852,000 ($1.1 million in 2001 dollars). From 1990 through 1998 there was not commercial harvest in the estuary except in 1996 (PFMC, 2005a). Based on an estimated 1996 harvest of 43,276 fall and spring Chinook salmon at an average weight of 13.5 pounds per fish, PacifiCorp estimated revenue from the 1996 tribal commercial catch at $525,000 ($575,000 in 2001 dollars). The decrease in total revenue is partially explained by the decrease in weight and number of fish, but because of increased supplies from other sources, the market price for salmon had also fallen from 1989 to 1996. Commercial harvests in subsequent years peaked at 17,095 fish in 2003 (see table 3-56), but was zero in 4 of the 11 years since 1996, including 1997, 1998, 2005, and 2006 (preliminary).

In addition to commercial harvest, these tribes also fish salmon for subsistence and ceremonial purposes. As noted in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*, the subsistence fishery has sometimes exceeded the tribes' commercial fishery, but in 2003 and 2004 the trend was reversed, with the commercial harvest more than double the subsistence fishery. In its comments on the draft EIS, the Yurok Tribe provided additional information with respect to that tribe's commercial harvest, noting that for the past 15 years, the Tribe has not had any commercial fisheries for species such as spring Chinook salmon, coho salmon, steelhead, lamprey, eulachon, and sturgeon because of their concern for the status of those species. In only 4 of those years did the Yurok have a minimal commercial fishery for fall Chinook salmon, while in the remaining 11 years the Tribal Council determined that the projected abundance of Klamath fall Chinook salmon was insufficient to support a commercial fishery.

In its comments on the draft EIS, the Yurok Tribe also presented survey data related to the effect of tribal commercial fishery closures on tribal members. They note that the survey results indicate that the hardships associated with the commercial fisheries closures have had a greater impact on respondents living within the ancestral territory than those living elsewhere, and that those losses have disproportionately affected those respondents who receive food assistance (table 3-114).

Table 3-114. Losses associated with tribal commercial fishery closures. (Source: Yurok Tribal comments on the draft EIS, filed December 1, 2006)

Losses Associated with Closure of Tribal Fishery	Respondents Reporting Losses (percent)	Respondents on Food Assistance Reporting Losses (percent)
Loss of income	22	33[a]
Increased food expenses	28	39[a]
Reduction in social and cultural activities	24	32[a]
Loss of goods and services received through barter and trade	18	28[a]
Increased financial stress	18	30[a]
Reduced income from secondary business	8	13[a]
Applied for public assistance due to closure	8	21[a]

[a] Significantly greater proportion of respondents on food assistance affected, Chi-square test, $p<0.05$.

Irrigated Agriculture

Reclamation's Klamath Irrigation Project provides irrigation water for both agricultural and wildlife refuge lands in the Klamath River Basin. In addition, the Klamath Irrigation Project provides flood control along the Klamath River and downstream of the hydroelectric project. The Klamath Irrigation Project provides irrigation water to approximately 240,000 acres of agricultural land, most of which is in Klamath County, Oregon, and Siskiyou and Modoc counties, California. According to the 1997 Census of Agriculture, 1,744 farms and ranches used irrigation water supplied by the Klamath Irrigation Project. Approximately 50 percent of these farms are in Klamath County and 30 percent are in Siskiyou County, both located in the six-county study region. The remaining 20 percent are in Modoc County, outside the study region.

The water diverted by the Klamath Irrigation Project from Keno reservoir supports about 490 farms, or 41 percent of the total number of farms supported by the irrigation project, and irrigates about 95,600 acres of irrigation project farmland and 4,000 acres of non-project farmland. Thus, water diverted through Keno reservoir irrigates about 45 percent of the total irrigated acres in the Klamath Irrigation Project. As noted in section 3.3.8.1.1, *Demographic Characteristics*, agricultural employment in Klamath and Siskiyou counties is substantially higher than in the other study region counties. Although the area irrigated by the Klamath Irrigation Project does not account for all the agricultural income in the two counties, it does contribute to the high agricultural employment.

3.3.8.2 Environmental Effects

In section 3.3.8.1.2, *Project-Related Economic Sectors*, we discuss current project-related effects in terms of project employment, payroll, and taxes; recreation; commercial fishing; the tribal fishery; and irrigated agriculture. In this section of the EIS, we consider the extent to which proposed and recommended changes in project operations may affect those same socioeconomic resources. We consider the socioeconomic effects of PacifiCorp's Proposal and other recommendations as they relate to four issues: (1) the effects of relicensing the project on the socioeconomic conditions of communities influenced by project operations; (2) the potential effect of PacifiCorp's proposed change in the project boundary to exclude East Side, West Side, and Keno developments on socioeconomic conditions of communities in the vicinity of these developments; (3) the potential effects on socioeconomic conditions

of retiring additional developments; and (4) whether relicensing the project would disproportionately affect any minority and low-income populations.

3.3.8.2.1 Project Employment, Payroll, and Taxes

The project's current direct employment (19 people), payroll ($820,000 annually), and taxes (about $2.8 million annually[154]) are relatively small in the context of the six-county economy. PacifiCorp has not proposed and other parties have not recommended measures specifically designed to affect employment, payroll, or taxes. However, PacifiCorp's proposal to remove East Side, West Side, and Keno developments from the project would affect those parameters. Similarly, recommendations to remove additional developments from the project would affect project employment, payroll, and taxes.

Our Analysis

East Side, West Side, and Keno developments are all located in Klamath County, and their removal from the project would reduce PacifiCorp's tax payments to Klamath County by 31 percent ($490,000), or about 1.4 percent of Klamath County's $35 million annual tax revenue. It would also eliminate PacifiCorp's annual tax payment to the city of Klamath Falls. Removal of these developments also would have a small negative effect on project employment and payroll.

The potential direct effects of retiring other developments would vary by development. Retirement of J.C. Boyle and Fall Creek developments, added to removal of East Side, West Side, and Keno developments, would eliminate the remainder of the tax payments to Klamath County, or about $1.1 million, almost all of which would be associated with retirement of J.C. Boyle development. Retirement of Copco No.1, Copco No. 2, Fall Creek, and Iron Gate developments would eliminate the taxes currently paid to Siskiyou County by about $264,000, $297,000, $22,000, and $506,000 respectively, or about 18 percent of the county's property tax revenue. Retirement of these developments also would mean the loss of all or most of PacifiCorp's jobs and payroll in the area, although, as we note above, these are small compared to the size of the area economy.

In our evaluation of PacifiCorp's proposal to remove Keno development from the project and other parties' recommendations to retire other developments, we considered dam removal as well as retirement with the facilities left in place. In section 4.7, *Conceptual Costs of Dam Removal*, we give an estimated cost for removal of each dam and describe how the removal could be accomplished. Short-term employment associated with removal of the dams could total about 85 full-time equivalent (FTE)[155] jobs and $6.3 million dollars in earnings, including those at Keno development (3.4 FTEs; $251,600 in earnings), J.C. Boyle (18.9 FTEs, $1,398,600 in earnings), Copco No. 1 (20.4 FTEs; $1,509,000 in earnings), Copco No. 2 (3.7 FTEs; $73,800 in earnings), Fall Creek (1.4 FTEs; $103,600 in earnings), and Iron Gate (36.8 FTEs; $2,723,200 in earnings). Given the six-county study area's total employment of more than 250,000, the jobs associated with dam removal would provide a very small increase during the period of dam removal.

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[154]See footnote in section 3.3.8.1.2, *Project-related Economic Sectors*. This figure could be as low as $420,000. For our analysis, we assume that the $2.8 million figure is correct, and we base our analysis on that assumption.

[155]A full-time job in construction is equal to 1,600 work hours, or one person working 8 hours per day for 200 days per year. One FTE can be any combination of workers totaling 1,600 hours.

3.3.8.2.2 Recreation

Recreation Site Improvements and Resource Management

PacifiCorp proposes and other parties recommend numerous measures designed to create new or improve existing camping, hiking, boating, and other day-use sites at the project, as well as to improve public access and site operation and maintenance. In section 3.3.6.2.1, *Recreation Resource Management*, we describe those measures and the anticipated effects on recreation. In that section, we describe the effects of the measures in qualitative terms, such as providing more camping sites, easier access to bank fishing locations, more diverse hiking opportunities, and better maintained sites. Any attempt to translate these qualitative improvements into a quantitative measure of the number of recreation visits to the project would be purely hypothetical, and we do not make that attempt.

Our Analysis

Given our lack of a quantitative estimate of the effect of improved site conditions or site management on recreation days spent at the project, we cannot make any definitive estimate of their effect on socioeconomic resources, such as visitor spending. To provide some context for considering the potential socioeconomic effect of improved site conditions or site management, table 3-115 shows the effect on visitor spending if the number of certain recreation visitors increased by 5 percent and 15 percent. Table 3-115 reflects participation in activities such as camping, hiking, and boat fishing, and does not include more specialized activities such as whitewater boating, river sport fishing, and ocean sport fishing, which we address in later sections. Although our choice of 5 and 15 percent as measures of change is somewhat arbitrary, this is in keeping with the Oregon and California State Comprehensive Outdoor Recreation Plans, which indicate a projected growing demand by recreation users for boat launches, campgrounds (RV and tent), hiking trails, day-use facilities, and interpretation facilities (see section 3.3.6.1.1, *Regional Recreational Setting*), the same types of facilities proposed and recommended for the Klamath Hydroelectric Project.[156]

Table 3-115 indicates that, with spending per person per day held constant, a 5 percent increase in the number of recreation user days in the upstream subregion would increase total non-local visitor spending in the 5-mile corridor to $784,300 per year (about $37,300 above 2002 spending), while a 15 percent increase in recreation user days would bring spending in the same area to $858,995 per year (about $112,000 above 2002 spending). In the downstream subregion, a 5 percent increase in user days would raise spending in the 5-mile corridor to $855,944 to $997,694 (about $40,800 to $47,500 more than in 2002), and a 15 percent increase would raise spending in the same area to $937,463 to $1,092,713 (about $122,300 to $142,500 above 2002 spending).

[156]PacifiCorp (2004a) reports that recreation use in the study area is projected to increase by 47 percent by 2040, primarily due to projected population growth. Our estimates of 5 and 15 percent are not intended to reflect that growth, which is expected even without project improvements. These are estimates of a reasonable range of additional use that might be anticipated because of the addition of new facilities or improvements to existing ones under the conditions of a new license.

Table 3-115. Annual recreation use and associated expenditures of total and non-local visitors engaged in selected recreational activities in the upstream and downstream subregions in 2002 and with 5 and 15 percent growth. (Source: PacifiCorp, 2004a, and staff)

Primary Activity	Recreation Days (User Days)	Expenditure Per Person Per Day ($)	Total Expenditure by Local and Non-local Visitors	Total Expenditure by Non-local Visitors to the Project Area	Total Expenditure by Non-local Visitors, 5-Mile Corridor	Total Expenditure by Non-local Visitors, 50-Mile Corridor
Upstream Subregion[a]						
2002	186,460	$6.57	$1,225,138	$746,952	$746,952	$1,020,398
+5 percent	195,783	$6.57	$1,286,395	$784,300	$784,300	$1,071,418
+15 percent	214,429	$6.57	$1,408,909	$858,995	$858,995	$1,173,458
Downstream Subregion[b]						
2002	20,526	NA	$994,812 - $1,129,812	NA	$815,185 - $950,185	$815,185 - $950,185
+5 percent	21,552	NA	$1,044,553 - $1,186,303	NA	$855,944 - $997,694	$855,944 - $997,694
+15 percent	24,785	NA	$1,144,034 - $1,299,284	NA	$937,463 - $1,092,713	$937,463 - $1,092,713

[a] Upstream subregion activities include boat fishing, waterskiing, resting/relaxing, shoreline fishing, RV camping, other, and no primary activity; see table 3-110 for 2002 figures by activity.

[b] Downstream subregion activities include gold mining and camping; see table 3-107 for 2002 figures by activity.

NA = estimates not available

Removal of East Side, West Side, and/or Keno developments from the project might or might not affect the condition and use of the associated recreational facilities, including the Link River Trail and the Keno Recreation Area. The facilities could continue to be maintained for public use by PacifiCorp or other entities, depending on the outcome of future decommissioning plans and jurisdictional proceedings.

As noted in section 3.3.6.2.3, *Development Decommissioning and Dam Removal*, removal of Fall Creek diversion dams and Copco No. 2 dam would have little or no effect on recreational activities and, thus, on recreation-related spending in the project area. Removal of one or more of the remaining four mainstem project dams would likely focus visitor activities on more riverine activities rather than on reservoir-based activities such as powerboating, waterskiing, lake swimming, and boat angling. Much of the current reservoir-based recreational use and associated spending would likely move to other areas of the region. This would include much of the camping and other activities that take place at project campgrounds. Although the recreational facilities could remain in place, the lack of proximity to a reservoir would decrease their attractiveness for many users. Much of the spending associated with these activities could remain in the six-county region and the 50-mile corridor, but would likely be lost to businesses in the 5-mile corridor. As we discuss in the following section, some or all of this loss of spending could potentially be replaced by the spending of other recreational users drawn to the new riverine opportunities.

Whitewater Boating and River-based Fishing

PacifiCorp proposes flow measures that would affect whitewater boating and river-based fishing opportunities in various parts of the project. Other parties, including Oregon Fish & Wildlife, Cal Fish & Game, the Bureau of Land Management, and NMFS recommend other flow measures. Detailed descriptions of the flow measures are provided in section 3.3.3.2.1, *Instream Flows*. The anticipated

effects of those flow measures on whitewater boating and river-based fishing opportunities are described in section 3.3.6.2.2, *River Recreation*. In that section, figures 3-108 through 3-135 graphically compare the whitewater boating and river-based fishing opportunities associated with various flow measures.

Our Analysis

Our analysis focuses on the likelihood that either an increase or decrease in optimal or acceptable flows would lead to an increase or decrease in recreation use of the project. Following our discussion of effects on recreation use, we discuss the potential associated increase or decrease in recreation-related spending in the project area. All analyses are based on a 7-month recreation season (April through October).

Link River Reach. Either decommissioning East Side and West Side developments or implementing Oregon Fish & Wildlife's flow recommendation would more than double the number of days when optimal angling flows would be available under current conditions for all 7 months in below average water years and 4 months in average water years (see figures 3-108 to 3-110). The same flow recommendations would produce opportunities similar to current conditions in 2 months in average water years and 1 month in above average water years, and would produce a lot fewer opportunities during 1 month in average water years and 6 months in above average water years. Thus, decommissioning or implementing Oregon Fish & Wildlife's flow recommendations would greatly increase angling opportunities in this popular reach during below average water years when other opportunities in the region would likely be scarce, and greatly reduce opportunities during above average water years when opportunities on other rivers would likely be greater. Although we cannot estimate how these opportunities might translate into actual recreation days, we conclude that implementing Oregon Fish & Wildlife's recommendation or decommissioning, as proposed by PacifiCorp, would likely lead to an increase in fishing overall.

Keno Reach. The agencies' flow recommendations and PacifiCorp's Proposal would maintain the status quo with respect to the Keno reach, and thus would not have an appreciable effect on angling and boating opportunities in this reach.

J.C. Boyle Bypassed Reach. PacifiCorp's Proposal, the Bureau of Land Management's flow specification, and the recommendations of Oregon Fish & Wildlife, Cal Fish & Game, and NMFS would all produce about the same number of days of acceptable angling flows in the bypassed reach during 7 months in below average water years and 5 months in average and above average water years (see figures 3-111 to 3-113). Compared to PacifiCorp's proposal and current conditions, the agency recommendations would reduce the number of days with acceptable flows during 2 months (April and May) in average water years and 2 months (April and June) in above average water years, both times when fishing opportunities are likely to be available in other regional rivers and streams. We conclude that PacifiCorp's Proposal and the agency flow recommendations would not likely have an appreciable effect on fishing overall. By contrast, removal of J.C. Boyle dam would diminish the number of days of acceptable angling flows by 15 to 90 percent in almost all months of below average and average water years and completely eliminate acceptable angling flows during 4 months in above average water years.

Regarding kayaking opportunities, in average and above average water years, PacifiCorp's and the Bureau of Land Management's measures would provide only occasional opportunities during April, May, and June and essentially no opportunities in July through October. However, there would be frequent opportunities for kayaking in July through October under the Oregon Fish & Wildlife flow recommendation and dam removal in all three water year types, and our conclusion is that there could be substantially more technical kayaking use of the bypassed reach under the Oregon Fish & Wildlife flow recommendation or with dam removal.

J.C. Boyle Peaking Reach. The analysis we present in section 3.3.6.2.2, *River Recreation,* concludes that continued peaking operations as PacifiCorp proposes would provide enhanced whitewater

boating (commercial rafting) opportunities at the peaking reach, particularly in above average water years (see figures 3-121 to 3-123). In general, it would provide between 20 and 30 days per month from June through October in below average and average water years and from July through October during above average water years. Our conclusion is that commercial rafting use of the peaking reach would likely increase somewhat under PacifiCorp's Proposal. Because the increase in whitewater flow days would be primarily in above average water years when flows would likely be high in other regional rivers as well, the expected increase in use would likely not be proportional to the increase in whitewater flow days.

The Bureau of Land Management measure would provide about 4 days a month between June and October, which would represent only about 13 to 20 percent of the days that would be provided by PacifiCorp's proposed flow measure. Commercial rafting opportunities would be largely eliminated between April and October under the Cal Fish & Game and Oregon Fish & Wildlife measures and dam removal scenarios, each of which would result in run-of-river operation (see figures 3-121 to 3-123).

With respect to angling opportunities in the peaking reach, we conclude in section 3.3.6.2.2, *River Recreation*, that the opportunities associated with PacifiCorp's proposal and the agency recommendations would all be roughly comparable to current conditions.

Copco 2 Bypassed Reach. The analysis we present in section 3.3.6.2.2, *River Recreation,* concludes that the agency recommendation and dam removal scenario would enhance whitewater boating opportunities in this reach by providing about 15 to 30 days a month with boatable flows from June through October (figures 3-130 to 3-132), while PacifiCorp's proposed operation would provide less than 10 days per month and these would occur primarily in April and May, and only in average and above average water years. Very few days with angling opportunities within an acceptable range of flows would occur under any of the flow-related measures or the dam removal scenario (see figures 3-133 to 3-135). We conclude that whitewater boating use of the bypassed reach could increase under the agency-recommended flows or dam removal scenario.

Below Iron Gate Dam. Whitewater boating opportunities below Iron Gate dam are affected by the base flow requirements set by the NMFS BiOp. Because this is not a project-related effect, we do not consider its effect on recreational boating.

As we note in our discussion of other recreational use of the project, it is not usually possible to reliably translate a change in opportunities to a change in actual recreation days. Following the same rationale we established in table 3-109, table 3-116 shows the change in spending that would result from a 5 or 15 percent increase in participation in river-based activities if spending per person per day remained constant. For example, a 5 percent increase in the number of whitewater boating days in the downstream subregion would bring total non-local visitor spending in the 5-mile corridor to $390,239 to $605,585 per year (about $18,600 to $28,800 above 2002 spending), while a 15 percent increase in recreation days would bring spending in the same area to $427,404 to $663,260 per year (about $55,800 to $86,500 above 2002 spending). In the downstream subregion, a 5 percent increase in sport river fishing would raise spending in the 5-mile corridor to $725,445 (about $34,500 more than in 2002), and a 15 percent increase would raise spending in the same area to $794,535 (about $103,600 above 2002 spending). Thus, the flows proposed by PacifiCorp and recommended by agencies that would potentially increase recreation days would generally increase recreational spending in the 5-mile corridor, and even in the 50-mile corridor, by less than $100,000 per year, and probably substantially less. On the other hand, flow measures or dam removal that would reduce or eliminate activities, such as commercial rafting in the J.C. Boyle peaking reach, could eliminate $465,567 to $739,374 in spending in the upstream and downstream region 5-mile corridor and $2.2 million to $2.5 million in spending in the 50-mile corridor. Because commercial outfitters that run trips on the peaking reach depend on that reach for most of their business, those that could not run trips on other rivers would likely go out of business.

Table 3-116. Annual recreation use and associated expenditures of total and non-local visitors engaged in whitewater boating and river-based angling in the upstream and downstream subregions in 2002 and with 5 percent and 15 percent growth. (Source: PacifiCorp, 2004a, and staff)

			Total Expenditure			
Primary Activity	**Recreation Days (User Days)**	**Expenditure Per Person Per Day ($)**	**Local and Non-local Visitors**	**Non-local Visitors to the Project Area**	**Non-local Visitors, 5-Mile Corridor**	**Non-local Visitors, 50-Mile Corridor**
Upstream Subregion[a]						
Whitewater Boating - 2002	5,090	$134.25 - $149.35	$683,333 - $760,191	$55,736 - $63,880	$93,911 - $162,626	$627,597 - $696,311
+5 percent	5,345		$717,500 - $798,201	$58,523 - $67,074	$98,607 - $170,757	$658,977 - $731,127
+15 percent	5,854		$785,833 - $874,220	$64,096 - $73,462	$107,998 - $187,020	$721,737 - $800,758
Downstream Subregion[a]						
Whitewater Boating - 2002	13,673	NA	$1,566,226 - $1,771,319	NA	$371,656 - $576,748	$1,566,226 - $1,771,319
+5 percent	14,357	NA	$1,644,537 - $1,859,885	NA	$390,239 - $605,585	$1,644,537 - $1,859,885
+15 percent	15,724	NA	$1,801,160 - $2,037,017	NA	$427,404 - $663,260	$1,801,160 - $2,037,017
River Sport Fishing - 2002	28,432	NA	$1,486,990	NA	$690,900	$655,070
+5 percent	29,854	NA	$1,561,340	NA	$725,445	$687,824
+15 percent	32,697	NA	$1,710,039	NA	$794,535	$753,331

[a] 2002 figures are from table 3-106.

NA = estimates not available

3.3.8.2.3 Commercial Fishing, Recreational Ocean Fishing, and the Tribal Fishery

As we describe in section 3.3.3.1.5, *Salmon and Steelhead Harvest and Harvest Management*, PFMC harvest-related actions for fall Chinook salmon are triggered by whether there are predicted to be at least 35,000 natural spawners returning to the Klamath River in a given year. Where insufficient returns to the Klamath River trigger restricted fishing seasons or closures, the economic effects go far beyond the value of the Klamath River salmon, because the season is restricted or closed for other fish as well. Thus, virtually all of the measures proposed by PacifiCorp or recommended by other parties that would affect Klamath River fall Chinook salmon also would affect the commercial, tribal, and recreational ocean fishery. Because all those fisheries depend upon the same fish populations, we discuss the socioeconomic effects of all the fisheries here. We describe the relevant proposed and recommended resource measures and their potential effects on aquatic resources in detail in sections 3.3.3.2.1, *Instream Flows*; 3.3.3.2.2, *Fish Passage*; 3.3.3.2.3, *Disease Management*; 3.3.3.2.4, *Dam Removal or Decommissioning;* and 3.3.3.2.5, *Anadromous Fish Restoration*.

Our Analysis

Table 3-106 in section 3.3.8.1.2, *Project-related Economic Sectors*, indicates that spending in the 5-mile and 50-mile corridors related to recreational ocean fishing equaled $4.3 million in 2002, which makes it by far the most important recreational economic sector related to management of the Klamath

River Project. That spending was associated with 93,235 recreation days, including 7,612 commercial user days and 85,623 private user days. Table 3-107 in the same section indicates that personal income from the KMZ personal salmon fishery ranged from $3.1 to $8.1 million dollars from 1976 through 2005, with preliminary figures equaling $3.3 million in 2005 (in 2005 real dollars), or 59 percent below the 1986-1990 average. This decline is associated primarily with decreasing angler trips, which in turn are based on fewer fish and the shorter fishing seasons prescribed by PFMC.

Table 3-108 in the same section indicates that personal income from the KMZ commercial troll salmon fishery averaged $43.1 million annually from 1976 to 1980, fell to as low as $1.2 million from 1991 through 2000, and since 2000 has ranged between $13.8 million in 2003 and a preliminary figure of $4.1 million in 2005 (PFMC, 2006). The lower figures since the 1970s are attributable to many factors, but particularly to declining numbers of fish and the resulting restricted fishing season.

As we describe in section 3.3.8.1.2, *Project-related Economic Sectors*, the value of the tribal commercial fishery in 2001 is estimated at about $195,590 (PacifiCorp, 2004a). Salmon are also an important subsistence resource (see section 3.3.8.2.4, *Minority and Low Income Populations*).

In addition to the adverse effect that declining Klamath River stocks have had on incomes in the KMZ communities, the effect of harvest restrictions has had a much more widespread effect, leading to harvest restrictions throughout the entire west coast fishery. In June 2006, California Governor Schwarzenegger proclaimed a state of emergency in 10 California counties due to PFMC's harvest restrictions along the coast of California and Oregon. Reports in the press cite a figure of $81 million in losses "that fishermen and fishing dependent communities are expecting to endure because of the Klamath River fishery collapse" (Whitney, 2006).

In our analysis, we define several scenarios as a means of analyzing the results of combining various proposed and recommended measures with respect to instream flows, fish passage, disease management, anadromous fish restoration, and dam removal or decommissioning. For the reasons described in detail in section 3.3.3.2, we summarize our conclusions as follows:

Best Case Without Dam Removal. The best case that does not include dam removal would provide for volitional passage or trap and haul passage to the upper basin, and would have to solve the mainstem corridor disease problems. The estimated results of this scenario would include the following:

- Chinook salmon ocean troll harvest in the KMZ returned to the 1986 to 1989 levels of 12,000 to 43,000 fish (see table 3-54);
- Chinook salmon ocean sport harvest in the KMZ returned to the 1986 to 1989 levels of 6,000 to 21,000 fish (see table 3-54);
- steelhead recreational harvest back to the 1985 to 1987 levels of 4,000 to 7,000 fish (see table 3-56);
- an additional 3,000 to 30,000 fall Chinook salmon due to successful passage (see table 3-76);
- an additional 1,300 to 2,700 spring Chinook salmon due to successful passage (see table 3-76); and
- an additional 300 to 400 steelhead due to successful passage (see table 3-76).

Best Case With Dam Removal. Removing Iron Gate and Copco 1 dams, providing volitional or trap and haul fish passage at Copco 2 and J.C. Boyle, and solving the mainstem corridor disease problems would be the best combination of actions for restoring the economic benefits associated with recreational, commercial, and tribal fishing. This option is the most likely route to successfully addressing problems with the downstream migratory corridor, and would allow inundated habitat within the project to return to production. It would produce results as good as or better than those described above for the *Best Case*

Without Dam Removal scenario. In its comments on the draft EIS, PacifiCorp states that there are many uncertainties associated with reintroduction and that there would be a total loss of the downstream C, N, and tribal fishery for the 10 to 20 years that it would take to restore the fishery after removing the dams and the hatchery. There is no doubt that there are many uncertainties associated with reintroduction. However, we are looking at dam removal options that would leave Iron Gate dam (and hatchery) in place for the first 5 or 10 years while adult salmon are trucked to upstream habitat, which would start the process of rebuilding upstream runs before the hatchery is shut down. There is some uncertainty as to whether this would be successful, but continued future salmon production of any sort is uncertain in any scenario given the disease problems in the lower river.

Middle Ground. Implementing measures that would not ensure that fish passage is immediately successful and that left some mainstem corridor disease issues unresolved would lead to a middle ground situation, including the following:

- Chinook salmon ocean troll quotas in the KZM remaining at the 2005 and 2006 levels of 7,100 to 8,400 adult fish (see table 3-53);
- Chinook salmon ocean sport quota in the KZM remaining at the 2005 and 2006 levels of 900 to 1,200 adult fish (see table 3-53);
- Chinook salmon federally recognized tribal harvest quota remaining at the 2005 and 2006 levels of 8,300 to 10,000 adult fish to the Yurok and Hoopa Valley tribal fisheries;
- no rebound in steelhead recreational harvest; and
- minimal increase in fall Chinook salmon, spring Chinook salmon, and steelhead due to successful passage.

Worst Case. In the worst case, mainstem corridor disease conditions would continue to worsen, and there would be no commercial, recreational, or tribal harvest of KMZ stocks. This would be the case regardless of whether fish passage was provided through the project.

Given these assumptions, the effect of relicensing on the local economy and the whole coastal economy would largely depend upon the degree to which the conditions of any new license address the issue of disease problems in the mainstem corridor, and thus the health of the Chinook salmon and the salmon fisheries.

3.3.8.2.4 Minority and Low Income Populations (Environmental Justice)

In section 3.3.8.1.1, *Demographic Characteristics*, we note that the per capita income of the American Indian population in each of the six counties in the study region is about 50 percent lower than that observed for the entire population in each of the counties. Additionally, with the exception of Curry County, the counties in the study region have a substantially higher percentage of low-income population among the American Indian population compared to the overall population. In its comments on the draft EIS, the Yurok Tribe noted that the California EPA's EJ Small Grants Program has awarded environmental justice grants to five federally recognized tribes in California (the Yurok, Karuk, and Hoopa Valley Tribes; Quartz Valley Indian Reservation; and Resighini Rancheria) for the purposes of completing environmental justice analyses of the project and its impact on each tribe. The Yurok Tribe indicates as well that the California State Water Resources Control Board has contracted with the same tribes to participate in an environmental justice pilot project for the purposes of evaluating project impacts on those tribes in its consideration of PacifiCorp's application for 401 water quality certification.

Because of the importance of salmon to tribal culture, the aquatic resource measures discussed above are equally relevant to project effects on minority and low income populations.

Our Analysis

As noted in section 3.3.3.1 5, *Salmon and Steelhead Harvest and Harvest Management,* the subsistence fishery has sometimes exceeded the tribes' commercial fishery, but in 2003 and 2004 the trend was reversed, with the commercial harvest more than double the subsistence fishery. The subsistence fishery provides a cultural benefit as well as a health benefit, however, based on the role of salmon in the tribal culture and because of the high levels of diabetes found among Yurok tribal members and the high levels of both diabetes and heart disease found among the Karuk Tribe (Norgaard, 2005). Norgaard's findings are consistent with the results of epidemiological studies conducted on tribes in various locations in the United States. For example, Smith-Morris (2004) reports that more than half of Pima Indians (southern Arizona) over 35 years of age have diabetes. The Indian Health Service (2006) states that diabetes is 4 to 8 times more common in American Indians compared to the general U.S. population. The causes for this disproportionately higher rate of diabetes (and its associated diseases, including heart and kidney disease) among Native Americans are believed to include genetics (e.g., the thrifty gene [Neel, 1982]), and a change from a traditional diet to a "modern" diet high in fat and carbohydrates (Dillinger et al., 1999). There is also an increasing trend in these diseases in the U.S. population at large, with the Center for Disease Control and Prevention indicating that the number of Americans with diagnosed cases of diabetes increased from 5.8 million in 1980 to 14.7 million in 2004, a 153 percent increase in 24 years (CDC, 2006). Nonetheless, diabetes affects American Indians/Alaska Natives disproportionately compared with other racial/ethnic populations, with one CDC study finding the age-specific prevalence of diagnosed diabetes being two to three times higher for American Indians/Alaska Natives than for all U.S. adults (Acton et al., 2003). Risk factors for the population as a whole have been identified as obesity, inactivity, and family history, among others.

The best, middle ground, and worst cases discussed above are relevant to the effects of relicensing on minority and low income populations, as follows:

Best Case With or Without Dam Removal. Given the level of anadromous fish production that could be achieved if anadromous fish were successfully restored to the upper basin and mainstem corridor disease problems were effectively addressed, this scenario would have a substantial positive effect on the harvest quotas available to the tribes to restore their commercial and subsistence salmon harvest to levels seen in the 1980s. Increased salmon populations and harvests would in turn allow access to a more traditional diet and lifestyle for the Karuks, Yuroks, and other tribes, resulting in improved physical, cultural, and spiritual health. Because it would include the restoration of salmon to areas where they have not been since construction of the Copco development in the early 1900s, this scenario would benefit the Klamath Tribes as well as the downstream tribes.

Middle Ground. Implementing measures that would not ensure that fish passage is immediately successful and that left some mainstem corridor disease issues unresolved would likely lead to a status quo or continued deterioration of salmon abundance in the river, which would at best leave the tribes in their current state and would at worst exacerbate their low income status, which under the concept of environmental justice would constitute a disproportionately adverse effect on minority and low income populations.

Worst Case. If measures are not implemented to substantially improve mainstem corridor disease conditions, the harvest of KMZ stocks could easily be eliminated entirely, exacerbating the low income status of the tribes that depend on the Klamath River stocks for income and cultural and dietary purposes. Under the concept of environmental justice, this would constitute a disproportionately adverse effect on minority and low income populations.

3.3.8.3 Cumulative Effects

3.3.8.3.1 Fisheries

Employment has grown consistently in the six-county region in the past 25 years, but at a pace slower than the Oregon and California averages. Employment growth has been accompanied by a shift in jobs away from the manufacturing sector and into other sectors, including services, retail trade, and government, as well as agriculture in some areas. Historically, communities along the coast were dependent on ocean commercial and recreational sportfishing. Along with commercial fishing, the coastal communities also depended on the packing and processing plants that prepared the fish for market. However, most of the packing and processing plants, whose employment used to be reported as part of the manufacturing sector, have closed.

The effects of continued project operation under PacifiCorp's proposed alternative, with implementation of measures recommended by other parties, or by retiring various developments would conflate with the effects of other past, present, and reasonably foreseeable future actions. A particularly important factor in the assessment of cumulative effects on socioeconomic resources is a pending action by PFMC to amend the Salmon Fishery Management Plan by which it manages the fall Chinook salmon harvest in the KMZ (see section 3.3.3.1.5, *Salmon and* Steelhead Harvest and Harvest Management, for additional information). PFMC submitted to NMFS for approval a Draft Environmental Assessment with a preferred alternative that would allow some harvest in years when Klamath River Chinook salmon escapement is not expected to reach the target of 35,000 adult spawners, as opposed to the current rule which calls for shutting down the fishery. After reviewing the data, and in collaboration with NMFS, the states, tribes, and fishermen, PFMC determined that conditions in 2007 would allow for the plan to be temporarily set at 21,000 fall Chinook salmon natural spawners, without compromising the long-term productivity of the stock. This action alone could increase the income potential associated with recreational and commercial ocean fishing by millions of dollars annually, regardless of the measures that are implemented at the Klamath River Project, and may temper the effects we describe above with respect to the middle ground and worst case scenarios on the ocean sport and commercial fisheries, as well as the tribal fishery.

Also important are the future actions taken by other parties. Because the blockage of Chinook salmon from historical upstream habitat is not solely the result of the project dams, the actions of other agencies, including Reclamation, would continue to affect the likelihood of salmon recovery in the Klamath River Basin, either supporting or running counter to actions taken at the Klamath River Project.

3.3.8.3.2 Indian Tribes

As noted throughout sections 3.3.8.1, *Affected Environment*, and 3.3.8.2, *Environmental Effects,* the tribal communities in the six-county study area experience significantly higher rates of food insecurity, poverty, and unemployment than non-Indian communities. Additionally, they suffer from substantially higher rates of some diseases, including diabetes and heart disease. These problems are linked to the loss of the tribes' traditional ability to rely on the Klamath River and its resources for their subsistence, culture, spiritual traditions and practices, and economic security. The blockage of Chinook salmon from historical upstream habitat as a result of the project dams and other actions in the Klamath Basin, as well as the degraded water quality resulting from project impoundments, upstream land management practices, and water management in tributary watersheds, have contributed to that loss.

3.3.8.3.3 Agriculture

During scoping for the Klamath River Project relicensing, several parties raised the issue of the April 16, 2006, expiration of the 1956 Contract between the California Oregon Power Company (Copco, which preceded PacifiCorp as owner of the Klamath Project) and Interior, which, among other things,

provided energy at below-market rates to Klamath Irrigation Project irrigators (see section 2.1.1.2, *Keno Development*). Expiration of the contract would increase the price of electricity used by irrigators to pump water to and through their irrigation systems, jeopardizing the profitability and even the continued viability of some agricultural operations. In light of the 1956 Contract expiration, the Oregon Public Utilities Commission and the California Public Utility Commission initiated proceedings to set the rates for irrigators that formerly received power under the contract. Both states ruled that the irrigators should be included under their standard irrigation rates. However, both states included "rate shock" provisions, whereby the transition to market rates would be phased in over 4 years (California) or 7 years (Oregon).

In a detailed evaluation of the relationship of energy pricing and irrigated agriculture in the upper Klamath River Basin, an Oregon State University Extension Service study (Jaeger, 2004a) reported the following findings:

(1) Under the contract, PacifiCorp has been providing energy to irrigators at about one-tenth the rate PacifiCorp charges irrigators not covered by the contract;

(2) Costs of farming would increase by roughly $40 per acre if the irrigators were paying market rates[157];

(3) Profits accruing to landowners using sprinkler irrigation would decline significantly with a change in energy pricing, but farming would not become unprofitable on Class II and Class III irrigated lands,[158]

(4) Sprinkler-based irrigated agriculture could become unprofitable on 193,000 Class IV and Class V lands, including about 88,000 acres in the Klamath Irrigation Project and 65,000 acres outside the irrigation project; and

(5) Irrigation diversions could decline as a result of price-induced water conservation on some irrigated lands and the cessation of irrigation on other lands.[159]

Jaeger concludes that most of the irrigated lands in the upper Klamath River Basin, and particularly those in the Klamath Irrigation Project, are highly productive and would continue to be profitable, although owners would experience lower profits. Nonetheless, water diversions would likely decline, especially on Class IV and V lands devoted to hay and pasture, which would become unprofitable to irrigate at higher energy prices. In its comments on the draft EIS, Interior states that Reclamation disagrees with many of the assumptions and conclusions of the Jaeger report, indicating that the cost per

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[157]Jaeger (2004a) provides more detailed estimates of per acre costs based on variations in crops, crop rotation, technology, pump size, number of acres irrigated, etc., and uses $40 per acre as a central estimate based on both energy consumption data and engineering estimates.

[158]Farmland soils are classified according to soil capability classes as follows: Class I soils have slight limitations that restrict their use; Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices; Class III soils have severe limitations that reduce the choice of plants or require special conservation practices, or both; Class IV soils have very severe limitations that restrict the choice of plants or require very careful management, or both; Class V soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover. Classes VI through VIII are not considered suitable for agriculture.

[159]Jaeger does not estimate the total decline in irrigation diversions that could occur, but notes that one-fifth (30,000 acres) of the Class IV and V sprinkler-irrigated lands represent about 7 percent of the total irrigated acres in the upper basin but only about 3.5 percent of the net income from irrigated agriculture. The consumptive water use on these 30,000 acres of hay and pasture is about 75,000 acre-feet (Jaeger, 2004a).

acre used by Jaeger is not consistent across Reclamation's Klamath Irrigation Project, and some of the most productive lands would have a disproportionate increase in power costs compared to the rest of the irrigated lands. Additionally, Interior states that 88,000 acres is a significant portion of the Klamath Irrigation Project, the loss of which would cause severe effects within the agricultural support industry. In its comments on the draft EIS, KWUA also states reservations about the Jaeger report, noting that Jaeger's evaluation assumed not only the termination of power rates under the 1956 contract, but also the rates afforded in a distinct area of the Upper Klamath Basin under a completely separate contract. KWUA also commented that Jaeger did not acknowledge that irrigation water users in the Klamath Irrigation Project pay not only the costs associated with their own pumping, but also reimburse electric costs incurred by irrigation districts and Reclamation.

Interior also notes that Jaeger did not take into account the effect of changes in cropping patterns on the food source for the national wildlife refuges, which Interior refers to as a major contributor to the local economies. In its comments on the draft EIS, KWUA notes that an increase in pumping costs could also lead to less water being pumped into the Lower Klamath National Wildlife Refuge. If the water supply to any of the refuges is decreased, conditions on the refuges would likely more closely resemble pre-irrigation project conditions and therefore, refuge managers may need to adjust refuge management plans to emphasize wildlife species less dependent on water.

The implication of Interior's and KWUA's comments is that the effect of the electricity price increases on irrigators and the economy would be worse than predicted by Jaeger. In its comments on the draft EIS, KWUA notes that these impacts would include adverse effects on employment, local governments, and other socioeconomic values. The effects would be likely to unfold over time because of the multi-year phase-in of market rates that is provided for by both the Oregon and California Public Utility Commissions.

With respect to actions implemented at the Klamath River Project as the result of a new license, any actions that would have adverse socioeconomic effects would add to the negative consequences of this loss of agricultural profit and related economic activity, while measures that had positive socioeconomic effects might offset some or all of the agricultural income loss to the regional economy.

3.3.8.4 Unavoidable Adverse Effects

If the project is relicensed as proposed by PacifiCorp (which does not include provisions for anadromous fish passage among the environmental measures it plans to implement), the project would continue to block anadromous fish from the upper Klamath River Basin. Relicensing the project without the removal of mainstem project dams would likely result in upstream and downstream passage delays, as well as some mortality of outmigrating smolts, even with the implementation of fishways (either volitional or other). Without removal of Iron Gate or Copco No. 1 dams, water quality conditions downstream of Iron Gate dam would continue to adversely affect Chinook salmon and steelhead during their outmigration through the lower Klamath River. This would continue to have a depressing effect on socioeconomic sectors dependent on the salmon harvest.

3.3.9 Cultural Resources

3.3.9.1 Affected Environment

3.3.9.1.1 Definition of Cultural Resources, Historic Properties, Effects, and Area of Potential Effects

Historic properties are cultural resources listed or eligible for listing in the National Register of Historic Places (National Register). Historic properties can be buildings, structures, objects, districts (a term that includes historical and cultural landscapes), or sites (archaeological sites or locations of

important events). Historic properties also may be resources of traditional religious and cultural importance to Native American tribes that meet the National Register criteria; these properties are known as Traditional Cultural Properties (TCPs). In most cases, cultural resources less than 50 years old are not considered eligible for the National Register. Cultural resources also have to have enough internal contextual integrity to be considered historic properties. For example, dilapidated structures or heavily disturbed archeological sites may not have enough contextual integrity to be considered eligible.

Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended (section 106), requires "federal agencies" including the Commission, to consider the effects of their undertakings on historic properties. An undertaking means a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a federal agency, including, among other things, processes requiring a federal permit, license, or approval. The Advisory Council on Historic Preservation's (Advisory Council's) regulations implementing section 106 define effects on historic properties as those that change characteristics that qualify those properties for inclusion in the National Register. In this case, the undertaking is the proposed issuance of a new license for the project; potential effects of relicensing may result from day-to-day operation and maintenance of the project, or from other actions required by the license, such as those associated with land or natural resource management, or recreation.

Determination of effects on historic properties first requires identification of historic properties in the area of potential effects (APE) of an undertaking. The Advisory Council's regulations define the APE as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. APEs for relicensing of hydroelectric projects normally include lands within the project boundary as it is delineated in the existing FERC license, plus any locations outside the project boundary where continued project operations may affect the character or use of historic properties. The APE proposed by PacifiCorp in its 2004 application was defined including project hydropower facilities, recreation sites, and proposed wildlife enhancement lands, and encompassed all lands within the current project boundary, all lands within PacifiCorp's proposed project boundary (see section 2.2.4, *Proposed Project Boundary*), and river reaches downstream of each development. In March 2006, PacifiCorp filed a revised HPMP that includes a revised APE. PacifiCorp's revised APE, based on the company's proposed revisions to the project boundary and to the company's belief that it had originally overestimated the potential for project effects, excluded Keno reservoir, the Klamath River from Keno reservoir to the head of J.C. Boyle reservoir, and the river reach from just below J.C. Boyle powerhouse to the Oregon-California state line. Neither the Oregon nor the California State Historic Preservation Officers (SHPO) has concurred with either PacifiCorp's initial (2004) APE or its revised APE of 2006. We discuss the APE further in section 3.3.9.2.2.

The Advisory Council's regulations also require the Commission to seek concurrence from the SHPO on any finding involving effects or no effects on historic properties, and allow the Advisory Council an opportunity to comment on any finding of adverse effects. In addition, the regulations require the Commission to consult with interested Native American tribes that might attach religious or cultural significance to historic properties within the APE.

3.3.9.1.2 Cultural History Overview

The project is located in a region of overlapping cultural traits from the California, Great Basin, and Columbia Plateau culture areas. The earliest human occupation of the area occurred in the Paleoarchaic period (12,000 to 7,000 years before present [B.P.]). These people were hunter-gatherers with a broad-spectrum subsistence economy geared toward large game animals and supplemented by fish, birds, and plants. High seasonal and annual mobility, low population densities, and a technology geared toward maximum flexibility define this period. The Early Archaic period (7,000 to 4,500 B.P.) witnessed the first use of semisubterranean house pits in the Plateau region, suggesting at least some people were living a less mobile lifestyle. During the Middle Archaic period (4,500 to 2,500 B.P.), there was an increased use of riverine and marsh environments (salmon and root species). The Late Archaic/Late

Prehistoric period (2,500 to 200 B.P.) saw numerous changes to the social framework, including the widespread use of pit houses, a heavy reliance on fishing, the use of storage pits for salmon, exploitation of the roots and bulbs of the camas lily, and emergence of seasonal land use patterns. This is the period when bow and arrow technology developed. Extensive trade networks were in place by 1,500 B.P., as evidenced by archaeological sites containing obsidian tools made from material found at sources more than 100 miles away.

At the time of contact with Euroamericans in the early 19th century, seven Native American tribes of various language groups counted portions of the Klamath River drainage as part of their ancestral territories. The Klamath and Modoc tribes, as well as some elements of the Snake peoples, were located in the upper reaches of the drainage. The Shasta (whose territory primarily consisted of river systems located at an elevation above 2500 feet) were represented along the Klamath River by one of the tribe's four internal subgroups, the Wairuhikwaiiruka or Kammatwa. The Karuk tribe was most closely associated with the middle reaches of the Klamath River, while ancestral territory of the Yurok included not only the lowest reach of the river and mouth but also stretches along the Pacific coast. The Hoopa were less closely associated with the mainstem of the Klamath River, their ancestral territory focused more on the Trinity River, a main tributary of the Klamath River.

Although the Klamath River tribes are from various language groups and have their own distinct cultural traditions and practices, they derived their cultures and subsistence wholly (the Klamath, Shasta, Hoopa, and Karuk), or in large part (the Yurok), from the river and its aquatic and terrestrial resources. Salmon, steelhead, and other fish (such as suckers and lampreys), taken with weirs, nets, baskets, harpoons or spears occupied a central place in the diets of these peoples. As a result, fish (particularly salmon) were at the foundation of the tribes' settlement and seasonal subsistence patterns and remain at the core of their belief systems.

The salmon runs themselves played an important role for the tribes, not just for sustenance, but for ceremonies and traditional rituals. The Karuk and Yurok tribes, for instance, recognized two runs of Chinook salmon, with the First Salmon Ceremony performed at the beginning of the spring run when the fish first breached the sandbar at the mouth of the Klamath (Salter, 2003). Traditionally, salmon could not be eaten until after this ceremony when the medicine man would eat the first salmon. The World Renewal Ceremonies, or Pikiavish Ceremonies, were shared among the Karuk, Yurok, and Hoopa tribes and were timed to the fall salmon run. The Shasta recognized three anadromous fisheries, beginning with Chinook salmon in April, steelhead following in August, and coho and chum salmon in October, and observed their own version of the First Salmon Ceremony (Daniels, 2006). Farther upriver, many of the largest Klamath and Modoc villages were specifically placed near salmon fishing sites, and multivillage and multitribal gatherings centering on the salmon harvest constituted important social and ceremonial events (Deur, 2003).

Other terrestrial and aquatic species such as crayfish, mussels, otters, deer, and the Pacific giant salamander are integral to the tribes' food, culture, and religion. Crayfish are included as part of the World Renewal Ceremony. As a prized game species, deer hunting required ritual acts to prepare the hunter. The Karuk Tribe used both deerskins as well as martin and otter skins during various ceremonies. The Pacific giant salamander, or puuf puuf, carries cultural significance in Karuk mythology as the creature responsible for purifying water.

The Klamath River tribes also made extensive use of a wide variety of plants from riparian and upland environments not only for food but also as raw material for clothing, tools, weapons and domestic items, and for medicinal and ceremonial purposes. Although the particular biotic environments each of the tribes occupied were the primary plant sources for each tribe, extensive travel and trading up and down the river made plant materials from throughout the Klamath River drainage (and beyond) available to all the tribes. The Yurok manufactured canoes from fallen redwood, as did the Klamath from ponderosa pine. Roots of redwood, pine, spruce, alder, willow and cottonwood were gathered, most

frequently along the river banks where they were easily harvested with minimal disruption of the trees themselves. Riparian environments were a rich source of edible fruits (huckleberry, gooseberry, currant, grapes, and sallal), and upslope locations provided filberts and acorns. Other food was derived from wocas (yellow pond lily), cattail, camas bulbs, and a wide variety of seeds and roots. Plant materials such as willow shoots and bark, hazel withes, grapevines, beargrass, ferns, nettle, cattail, tule, and woodwardia found use in the manufacture of nets, baskets, and other items. Even leaves of wild iris, gathered at much higher elevations, were used to make fine mesh nets. Geologic and topographic elements (particular rocks or landforms along the river, as well as upland locations) were featured prominently in the tribes' cultural "maps" of their ancestral territories, as places of year-round or seasonal settlement, traditional fishing, hunting and gathering sites, and sites of spiritual and ceremonial significance.

The arrival of Euroamericans in the region greatly affected tribes along the Klamath River. Native populations suffered from introduced diseases, the dislocation and ultimately forced relocation of survivors, disruption of traditional subsistence patterns and resources, and eventual suppression of native religious practices and language in non-Indian schools. The earliest Euroamericans to appear were trappers, who arrived in the mid-1820s in search of fur-bearing animals. Next to come, during the period of 1841-1855, were scientific expeditions, among them the Klamath Exploring Expedition of 1850 which looked for potential gold mining sites and locations for settlement.

Permanent Euroamerican settlement in the Klamath River watershed began in the 1850s, on the heels of prospectors for gold. Completion of the Southern Emigrant Road, also known as the Applegate Trail, in 1846 brought prospectors to the region and helped to establish communities such as Henley (Cottonwood), Gottville, Happy Camp, and Somes Bar. Fertile soil, level terrain, and plentiful water sources also made various portions of the area favorable for agriculture and ranching. Large scale settlement did not occur, however, until after 1875 when the Topsy Grade Road was completed. This road could accommodate wagons and served as the main stage and mail route between Yreka, California and Linkville (Klamath Falls), Oregon.

Mining proved of limited importance in the Euroamerican development of the region, despite its effect on native inhabitants, and logging did not occur to any substantial degree until railroads reached the area. The Oregon & California Railroad (O&CRR) was the first railway through the region (1877), extending from Siskiyou County, California, to Jackson County, Oregon, en route from Sacramento to Portland. Other local railroads, developed to support logging operations, eventually supplanted the stage lines. The Southern Pacific Railroad Company acquired the O&CRR that same year, and by 1909 connected the Klamath River area to a nationwide market. Rail connection outside the local area provided relatively inexpensive and efficient transport for agricultural commodities to wider markets.

The local timber industry began in the 1860s with a sawmill constructed by the United States Army along the Wood River near Fort Klamath (1863), and a privately owned sawmill in the Keno, Oregon area (1869). Sustained logging enterprises first appeared in the mid- to late 1880s. Early companies were small, family-run businesses typically run by ranching families trying to supplement their income. In the early 1890s, larger scale logging companies such as Pokegama Sugar Pine Lumber Company and Klamath River Lumber and Improvement Company were established on the north rim of the Klamath River Canyon. The settlements that grew up around the logging companies provided loggers and businessmen with multiple services, including stores, post offices, and schools. Local ranchers and farmers frequently provided meat and produce to adjacent logging camps.

The acreage available for agriculture was greatly increased following the passage of the Reclamation Act by the United States Congress in 1902. The act allowed for a new round of homesteading as portions of the Klamath basin were "reclaimed" from wetlands for agricultural use. Increased demand for arable lands led to initiation of the Klamath Irrigation Project in 1905. Seven dams (including Link River dam), hundreds of miles of irrigation ditches and canals, and 45 pumping plants

were eventually built under the auspices of Reclamation for the project. Reclamation homestead allotments took place from 1917 to 1949.

Also in the early 1900s, the federal government created refuges within the Klamath watershed to preserve some areas of wetlands for wildlife habitat. In 1908, President Theodore Roosevelt created the 80,000-acre Lower Klamath Lake National Wildlife Refuge. The Tule Lake and Upper Klamath Lake National Wildlife Refuges were created in 1928. Wildlife conservationists were not pleased when portions of the Tule Lake National Wildlife Refuge, approximately 22,000 acres, were released to homesteading in the 1940s. In 1964, passage of the Kuchel Act ended homesteading on lands in the area of the Klamath Hydroelectric Project.

Although timber production declined in the early 1900s, the industry began to improve around 1910. In the mid-1920s, the Weyerhaeuser Timber Company built a major mill in Klamath Falls and was a major economic power in the area for decades. Rapid growth in the lumbering business occurred in the 1920s, resulting in construction of numerous spur railroads to support logging efforts and increased use of mechanized equipment. The Depression, however, brought operations to a halt. By 1932, timber production had fallen to 55 percent of the pre-Depression volume, and roughly half of all timber-related jobs were lost. Logging revived during World War II, but fell on hard times again in the late 20th century.

The first hydroelectric development in the Klamath basin was established in 1891 in the Shasta River Canyon below Yreka Creek to provide electricity to the town of Yreka. Four years later, the Klamath Falls Light & Water company built a generating facility on the east bank of the Link River (known as East Side) to supply power to the community of Klamath Falls. Both ventures soon attracted competitors: the Siskiyou Electric Power Company's Fall Creek plant (1903) serving Yreka, and the Klamath Light & Power Company's West Side plant on the Link River (1908) serving Klamath Falls.

By 1912, these and many other small producers throughout the region were brought together as the California-Oregon Power Company (Copco). Copco subsequently embarked on a period of major expansion, with its Copco No. 1 development (1918, expansion 1921-22) the first on the Klamath mainstem, and Copco No. 2 (1925). As a result of Reclamation's construction (1921) of Link River dam for the Klamath Irrigation Project, Copco rebuilt the old East Side facility (1924) and expanded the West Side plant (1920s). After World War II, regional population growth prompted a new round of hydroelectric power expansion with Copco's Big Bend (1958) and Iron Gate (1962) developments. While Iron Gate was still under construction, Copco was merged into Pacific Power & Light (today PacifiCorp). In 1966, a new regulating dam replaced a 1931 dam of equivalent function that had replaced an older dam and powerhouse built by the Keno Power Company in the early years of the 20th century.

Of the seven Native American tribes in the Klamath River drainage, two (Hoopa Valley and Yurok) today have their own reservation lands in this area—the Hoopa around the Trinity River, and the Yurok on the lower reaches of the Klamath River. Tribes whose ancestral territories lie upriver have experienced different fates, but all retain close traditional and cultural connections to the river and natural resources of the valley.

In the Klamath Treaty of 1864, the federal government set off a large area at the headwaters to which it relocated surviving Klamath, Modoc, and Yahooskin, today together known as "The Klamath Tribes." Ninety years later, however, both their government-recognized tribal status and their reservation were terminated, resulting not only in loss of the land base but also of much of their tribal identity. Through lengthy court action, the Klamath Tribes were able to regain their status as a federally recognized tribe in 1986, but have had to acquire such land as they now hold on their own.

The California Gold Rush and Rogue River Wars (1850-1857) pushed most of the Shasta out of their traditional Oregon and Northern California territory. The increasingly marginalized people formed small communities near ranches throughout northwest California and southwestern Oregon, including those at Frain Ranch and Bogus Tom Smith's Rancheria in the Klamath River area. These communities

were able to benefit somewhat from a 1910 amendment to the 1887 Dawes Act, that made vacant land available to "landless" Native Americans if properly allotted by an Indian Agent, but the Shasta have no official reservation or formal U.S. government recognition. Some Shasta, along with Karuk and Upper Klamath, live at the Quartz Valley Rancheria, established in 1938 as the Shasta and Upper Klamath Indian Reservation. Federal supervision of this Quartz Valley Reservation was terminated in 1967; since then the tribe has been gradually reacquiring land.

The Karuk Tribe, today one of the largest tribes in California, has a very small land base. The federal government did not establish a reservation specifically for the Karuk (although as indicated above some Karuk are members of the Quartz Valley Rancheria). Most Karuk live in Siskiyou County, primarily in the districts of Orleans, Happy Camp, and Yreka, and in the Forks of the Salmon region. The Karuk Tribe gained federal recognition in the 1980s.

The Klamath River Reserve in traditional Yurok territory was created by Executive Order in 1856; it encompassed a mile of land on each side of the Klamath River from the Pacific Coast to Tectah Creek, approximately 20 miles. The U.S. government established the Reserve with the intent of relocating members of the Yurok, Tolowa, and Hoopa Valley tribes. However, only the Yurok and a few Tolowa moved. As a result of an 1864 treaty (unratified) with the Hoopa and several other tribes, the Superintendent of Indian Affairs for the state of California that year announced the location of a new Hoopa Valley Reservation, the boundaries of which were formally defined 13 years later in an Executive Order. This reservation, early on known as "the square" for its shape, was established around the Trinity River from its confluence with the Klamath. In 1891, the Hoopa Indian Reservation was enlarged (again by Executive Order) to include the Yurok Tribe's Klamath River Reserve plus an "extension" covering 1 mile on either side of the Klamath River between the two formerly separate reservations. The following year, the entire newly-constituted reservation was opened to non-Indian settlement (following government "allotment" of selected land for tribal use), resulting in substantial displacement, particularly of members of the Yurok Tribe. Some Yurok eventually settled on the Resighini Rancheria near Klamath, California, a tract of land within the Klamath Reserve acquired by the federal government from rancher Augustus Resighini under the Wheeler-Howard Act of 1934.

In l988, the Hoopa Valley Reservation created in 1891 was partitioned into two: the original Hoopa square (for the Hoopa Valley Tribe), and a reservation for the Yurok that included both the original 1855 reservation at the mouth of the Klamath and the later upriver "extension." Within it lies the Resighini Rancheria, which was federally recognized in 1975 as the Coast Indian Community of the Resighini Rancheria.

3.3.9.1.3 Prehistoric and Historic Archaeological Resources

Prior to delineating its APE, PacifiCorp, in conjunction with the Cultural Resources Working Group made up of agency stakeholders and tribal representatives delineated a field inventory corridor for purposes of archaeological survey. This field inventory corridor encompassed the current and proposed project boundaries, riparian and hydrologically connected areas along project-affected reaches, and culturally sensitive lands within the Klamath River Canyon from ridgetop to ridgetop, or rim to rim.

PacifiCorp contracted with Historical Research Associates (HRA) to complete a pedestrian survey of the field inventory corridor. HRA defined pedestrian transect intervals based on landform and vegetation cover, but these transects were to be at greater than 10-meter intervals and oriented parallel to watercourses. At least one crew member was instructed to walk in (if dry) or adjacent to watercourses to systematically examine cut bank soil exposures. The pedestrian survey began in 2002 and was finished in 2003. This survey resulted in the documentation of 165 archaeological sites.

The prehistoric sites are divided into five types: (1) open-air sites, with flaked stone artifacts only; (2) open-air sites, with flaked stone and ground stone artifacts; (3) village or temporary habitation sites without apparent house pit features; (4) village or temporary habitation sites with house pit features;

and (5) special use sites (burial sites, rockshelters, pictograph sites, and quarries). HRA recommended 93 prehistoric sites, or components of sites, as "potentially eligible" for the National Register on the grounds that further testing would be required to confirm their information potential and eligibility under Criterion D. HRA also obtained sufficient field information to conclude that an additional 33 prehistoric sites or components appeared to meet National Register Criteria without the need for further survey. PacifiCorp agrees with HRA's evaluations.

The consultants identified five areas of multiple prehistoric sites, which they believe are all located in the same section of the river, as a potential National Register district. This potential archaeological district would include:

- various sites in the vicinity of Link River, including a house pit village site (JS-04) and Site CB-05, and sites near Upper Klamath Lake;
- a complex of non-house pit sites near Teeter's Landing (FH-14, FH-15, and FH-16);
- sites in the vicinity of J.C. Boyle reservoir (35KL1942, CB-2, CB-3, CB-20, JS-7, JS-5, JC03-9, and JC03-10);
- a fishing station complex called Laik'elmi (collectively Sites 35KL554/35KL17, 35KL20, and 35KL21/35KL786) on the west bank and 35KL567, 35KL18, 35KL578, 35KL19, and 35KL23/35KL566 on the east bank in the upper Klamath River Canyon; and
- three large village sites (CA-SIS-2403, JC03-01, and CB-10) near Copco reservoir.

Another archaeologist (Mack, 2003), who has been conducting research in the region unrelated to project relicensing, has suggested that the Freedom Site (CA-SIS-1721) and Lion's Village (CA-SIS-2646), located near one another on the east side of the Klamath River just below the California-Oregon border, and isolated finds associated with both sites, may also constitute a National Register-eligible prehistoric archaeological historic district.

Identified historic-period archaeological sites are categorized according to six historical themes: (1) logging; (2) agricultural settlements or features (homesteads); (3) commercial or educational enterprises; (4) cemeteries; (5) public works (hydroelectric); and (6) transportation. Sites yielding limited data, such as ditches, rock walls, and piled rock in agricultural fields are described as "minor agriculture-related sites." Four historic-period trash scatters could not be applied to any specific theme. HRA's evaluation states there are nine historic sites or components of sites potentially eligible for and six historic sites or components eligible for the National Register. PacifiCorp agrees with HRA's evaluations.

One potential historic period archaeological district is the Frain Ranch, which is associated with an early homesteader and the beginning of ranching and agriculture within the upper Klamath River Canyon. Included within the Frain Ranch property are the main ranch area (35KL578H) and portions of Sites 35KL567, 35KL1083, and JC03-29.

3.3.9.1.4 Historic Buildings and Structures

No buildings or structures in the APE have been listed in the National Register. PacifiCorp's cultural resource team conducted a survey and evaluation of all project facilities 41 years old or older in 2003 and prepared site documentation and individual resource forms, for potentially significant hydroelectric resources. PacifiCorp prepared a multiple property submission for the entire project to document these interrelated resources and multimodal groupings. The survey and evaluation documented 110 structures.

PacifiCorp and its consultants have evaluated 60 out of 110 structures as retaining sufficient integrity to relate their association with the project and possessing significance for association with the industrial and economic development of southern Oregon and northern California. National Register-

eligible resources include dams, water conveyance features (flumes, penstock lines, penstock intakes, spillways, spillgates, headgates, pipelines, spillway houses, tunnels, surge tanks, earthen canals), powerhouses, turbines, generators, substations, warehouses, gatehouses, gate hoist system/rails, guest houses, houses and garages, a mortared stone wall, timber cribbing, a coffer dam, an oil and gas shed, a cookhouse/bunkhouse, a transformer house/office, and a fish hatchery. The California SHPO provided its opinion that none of the Iron Gate complex's structures are eligible for the National Register (letter from Dr. K. Mellon, State Historic Preservation Officer, California Office of Historic Preservation, to M. Strickler, Hydro Resources Project Manager, PacifiCorp, dated May 28, 2003).

3.3.9.1.5 Traditional Cultural Properties

As a result of deliberations with the Cultural Resources Working Group, PacifiCorp funded tribal ethnographic studies prepared by the Klamath, Shasta, Karuk, and Yurok tribes. These studies combined ethnography with extensive oral interviews to describe each tribe's culture and relationship to the Klamath River. Although functioning as tribe-specific documents, they were also intended to be used in a separate, "integration" report on the importance of the river to the area's Native Americans as a whole. PacifiCorp submitted these reports to both SHPOs, either as part of the license application or in subsequent submissions as the reports were completed.

The Klamath Tribes' report (Deur, 2003), based largely on oral interviews and site visits on the part of the consultant in company with interviewees, identified 11 "riverine and lacustrine" locations (including settlements and fishing stations) associated with the tribes' historical, cultural, and economic reliance on salmonid fisheries as TCPs meeting National Historic Register eligibility criteria. Link River, Big Bend, and Miller Island Oxbow were locations of major settlements and associated burial and ceremonial sites, as well as numerous encampments and fishing sites. The latter was also an important center for wocas (yellow pond lily) seed collection. The other eight TCPs lie further upriver on the headwaters: (1) Chiloquin Forks; (2) Braymill/Cave Mountain; (3) Beatty Springs; (4) Knapp's Dam/Williamson River Canyon; (5) the mouth of the Wood River; (6) Klamath March/Wocus Bay; (7) Olene Gap; and (8) Rocky Ford/Jackson Creek. The first five sites were all traditional salmonid fishing sites. The last three locations were of importance to Klamath subsistence and culture, as gathering sites (particularly Klamath Marsh), and camp sites for hunting and trout fishing.

The report from the Shasta Nation (Daniels, 2006)[160] combines ethnographic research, records of interviews with Shasta elders from the 1980s, interviews with Shasta people from 2002-2003, and archaeological data. It describes the role of the Klamath drainage in Shasta culture and the changes to traditional hunting, fishing, gathering and ceremonial practices that result from Shasta contact with Euro-Americans. The report presents a list of Shasta village sites recorded in ethnographic literature, a much larger list of locations (with and without archaeological manifestations) which the Shasta consider traditional cultural properties, and a third enumeration drawn from the first two listing eleven locations eligible for the National Register. Among these locations are village and camp sites, places associated with ceremonial practices, and the Frain Ranch area, where many Shasta gathered in the late 19th century. Nine of the eleven eligible TCPs have archaeological manifestations.

The Karuk and Yurok ethnographies were in particular designed as foundations for the "integration" report. The Karuk Tribe's report (Salter, 2003) presented a broad discussion of the tribe's use of natural resources (flora, fauna, and geological resources) within the Klamath River corridor and the traditional centrality of the river and its resources (particularly salmon) to the tribe's subsistence, its material and spiritual culture, and identity. The report used ethnographic and other writings to describe the natural setting and early patterns of Karuk habitation in the river basin. Interviews with tribal

[160]This report was filed with the Commission in February, 2007, after issuance of the draft EIS.

members focused on their own and their recalled use of the river and its resources (water, fish, cultural features, and vegetation).

The Yurok Tribe's report (Sloan, 2003) also drew upon extensive ethnographical literature in its presentation of this tribe's historical relationship to the Klamath River, organized around the topics of natural resources (water, fish, landforms, vegetation), cultural features (ceremonial practices, fishing places, geologic features, gathering, and habitation), and other topics such as transportation, communication, language, and relations with neighboring up-river tribes.

The Klamath River Inter-Tribal Fish and Water Commission (KRITWFC) incorporated information from these tribal studies, plus information provided by the Hoopa Valley Tribe from a previous study unrelated to the relicensing of the Klamath River project, in the "integration report" (King, 2004) focusing on the Klamath River as a cultural "riverscape" eligible for the National Register for its association with the broad patterns of tribal culture including environmental stewardship, spiritual and ceremonial tradition and practice, and subsistence. This approach was developed through a "regulatory analysis" prepared by the Yurok Tribal Heritage Preservation Office (Gates, 2003) that classified the riverscape as a form of district (a district being one of the five types of historic properties defined in National Register Criteria), specifically an ethnographic/cultural landscape with a river as its focus. Elements contributing to the eligible riverscape, as described in the integration report, include the Klamath River and its associated water and landforms, its "living population" of fish, terrestrial fauna and plants, and specific locations associated with cultural beliefs and/or practices, including but not limited to archaeological sites.

3.3.9.2 Environmental Effects

In this section we consider how actions proposed by PacifiCorp and other parties could affect cultural resources. We consider project operations first, and then move on to consider the proposed actions to manage cultural resources.

3.3.9.2.1 Effects of Project Operations on Cultural Resources

Historic Buildings and Structures

Buildings and structures require maintenance, repair, and sometimes replacement of components if they are to remain functional. However, necessary repairs and upgrades to the structures could degrade the character-defining elements that qualify these resources for inclusion in the National Register. Underused historic buildings and structures are vulnerable to deterioration or even removal. In the following section, we evaluate the effects that proposed and alternative operations would have on historic project facilities (e.g., dams, powerhouses) and on buildings and structures historically associated with these facilities.

PacifiCorp proposes to continue operating the J.C. Boyle, Copco No. 1, Copco No. 2, Fall Creek (including the Spring Creek diversion facilities), and Iron Gate developments, and to undertake minor modifications at all but Copco No. 2 to improve operations or to manage aquatic resources. PacifiCorp also proposes to decommission East Side and West Side developments, and to remove Keno development from the licensed project.

Our Analysis

With continued project operation, historic facilities such as the dams and powerhouses would remain in active use, since they are integral to the functioning of the hydroelectric project. Other buildings and structures may become obsolete or simply unnecessary to project operation, potentially leaving them vulnerable to neglect or demolition. Continued use of historic buildings and structures, as

proposed by PacifiCorp for the developments retained in the project, would enhance the likelihood that they would be repaired as needed and maintained in good condition.

The decommissioning and removal from the project license of East Side and West Side developments would end the Commission's jurisdiction over these historic hydroelectric facilities, and potentially remove the facilities from the protection afforded by NHPA. No longer in productive use, these facilities could be adversely affected by demolition or by abandonment without provision for proper maintenance and repair. With decommissioning, the Commission would require PacifiCorp to include in its decommissioning plans provisions for resolution of such adverse effects on historic project facilities, developed in consultation with the Oregon SHPO. This would also hold true for decommissioning any other generating development in the project except for Iron Gate, whose facilities and related buildings and structures the CA SHPO has determined ineligible for inclusion in the National Register.

Archaeological Sites

Archaeological sites can be disturbed by any action (natural, animal, or human) that disturbs or destabilizes the soils or ground surfaces on which they occur. Sites on shorelines may be eroded by natural or project flows, changes in water levels and by wind- or boat-induced wave action. During drawdowns, normally inundated sites may be revealed and are subject to damage, both from authorized recreational activities and also from illegal "pothunting" (removal of artifacts) along the shorelines. Sites in upland locations may experience erosion from wind action or when their soils slide following heavy rains. Public use of both developed and "informal" recreation areas, as well as use of OHVs, frequently result in surface and subsurface disturbances that damage or destroy archaeological sites. Although many recreation-related effects on archaeological resources may be inadvertent, vandalism and unauthorized artifact collection are also associated with public use. Additionally, archaeological sites are susceptible to disturbance from grazing, excavation of irrigation canals, and construction of agricultural access roads.

In its application, PacifiCorp has argued that bank erosion in the Boyle peaking reach and below Iron Gate dam is attributable to flows above full project capacity (3,000 cfs at J.C. Boyle, 1,800 cfs at Iron Gate), and therefore that the effects of erosion to archaeological sites above the geographic limits of project capacity are not caused by project operations. However, the application also notes that archaeological sites "very close to the active channel" could be affected by project effects on geomorphology and sediment transport. In its revised HPMP, PacifiCorp also maintains that because the adjacent land-managing agency (Bureau of Land Management) regulates public access and recreational activities along the J.C. Boyle peaking reach, any effects on archaeological sites resulting from land use such as grazing and recreation are not attributable to the project.

Our Analysis

Fluctuation of water levels can destabilize soils and lead to seepage failure that affects not only shorelines but also archaeological materials that may be present in those soils. Erosion of soils containing archaeological materials can result in displacement or loss of artifacts, and also to exposure of artifacts making them vulnerable to unauthorized collecting or inadvertent damage. Because the project has limited ability to control high flows, it would follow that erosion from flows beyond the project's capacity would not be attributable to project operations. Within the J.C. Boyle peaking reach, we recognize that it is not possible to separate peaking flow fluctuations from natural fluctuations within the limits of project capacity, and thus it is not possible to attribute erosional effects on one or the other. However, absent project peaking flows, fluctuations would be fewer than with project operations. As discussed in section 3.3.1.2.5, *Fluvial Geomorphic Effects on Riparian Vegetation*, project-related flow fluctuations are inhibiting recruitment and growth of riparian vegetation in the fluctuation zone, which could leave landforms containing archaeological sites vulnerable to destabilization and erosion. Thus, we must conclude that erosional effects on cultural resources within the limits of project capacity in the J.C. Boyle peaking reach, and those caused by erosion within the limits of project capacity (e.g., undermining of

terraces containing archaeological sites that lie above the limit of project capacity) would be appropriately attributable to project operations.

The fact that Iron Gate dam is ungated means that PacifiCorp cannot control spillway flow, and that high flow change events below this dam are beyond PacifiCorp's control. However, as discussed in section 3.3.1.2.3, *Project Effects on Sediment Transport*, project effects on sediment supply contribute to adverse effects on recruitment and maintenance of young riparian vegetation below Iron Gate dam. Riparian vegetation helps stabilize land on river shorelines; thus adverse effects on riparian vegetation can result in destabilization of shoreline containing archaeological sites, thereby adversely affecting those sites. We also note that adverse effects on riparian vegetation also may be considered adverse effects on TCPs, specifically the Klamath Cultural Riverscape in which the totality of the natural environment is a contributing element.

The surface visibility of many archaeological sites leaves them vulnerable to damage or destruction. During archaeological surveys commissioned by PacifiCorp, archaeologists noted numerous instances of pothunting on reservoir margins, particularly at Keno and J.C. Boyle reservoirs. Archaeologists also described effects of vandalism, looting, and OHV use on sites in the river reaches, including the J.C. Boyle peaking reach. To the extent of PacifiCorp's obligations under the license to provide recreational and other public uses of project lands and waters, effects resulting from public access to locations containing archaeological sites may be considered attributable to project operations. PacifiCorp's HPMP contains measures for monitoring and, as necessary, further treatment of archaeological sites affected by the project, including those potentially subject to adverse effects from its proposed recreational measures (see section 3.3.6, *Recreation Resources*). We analyze PacifiCorp's proposals and agencies' recommendations for treatment of archaeological sites threatened by vandalism and other inappropriate activity further below in *Treatment of Archaeological Sites*.

The decommissioning of East Side and West Side developments, and the removal of these and Keno development from the project license, would end the Commission's jurisdiction over lands containing significant archaeological resources, potentially removing them from the protection afforded by NHPA. Additionally, removal of the hydroelectric facilities and re-grading could involve substantial ground disturbance by mechanical equipment and could inadvertently damage or destroy sites. In the event of decommissioning, the Commission would require PacifiCorp to include in its decommissioning plans provisions for resolution of adverse effects on archaeological sites and TCPs, developed in consultation with the SHPOs. This would also hold true for decommissioning of any other development in the project.

Traditional Cultural Properties

The Klamath Project area has been used by Native peoples since prehistoric times, and their modern day descendants continue to do so today. Places and elements (including but not limited to archaeological sites) that tribes consider part of their traditional culture and history may be affected in various ways by project operation, depending on the kind of resource and source or agent of the effect. In subsection *Archaeological Resources*, we previously discuss the effects of proposed and alternative operations on resources most commonly described as "archaeological" (in other words, significant for their information potential under National Register Criterion D). However, we note that many "archaeological" sites have other values for Native Americans (for example, association with traditional culture and lifeways that make them significant under National Register Criterion A). Thus, adverse effects on an archaeological site may also constitute an adverse effect on a TCP.

As discussed in section 3.3.9.1.5, *Traditional Cultural Properties*, studies by the Klamath Tribes have identified three locations in or adjacent to the project that they recommend as eligible for the National Register as TCPs. These TCPs (Link River, Miller Island and Big Bend) have played important

roles in the subsistence–and therefore cultural–traditions of the tribes, as locations in which the natural environment offered good fishing, gathering, and hunting areas.

Under PacifiCorp's proposed decommissioning of East Side and West Side developments, the reach between Link River dam and Keno reservoir would be removed from the project and from the Commission's jurisdiction, thereby also removing the Link River TCP (within which is a location for traditional ceremonial activities that has been recorded as an archaeological site) from the protections afforded by NHPA. On the other hand, the Millers Island Oxbow TCP (in which no archaeological sites have been identified) is located in the Klamath Wildlife Area and the Lower Klamath Wildlife Refuge.

The Klamath Tribes describe the Big Bend TCP on the J.C. Boyle bypassed reach as the former location of an important village and trading center visited by Shastas, Modocs, and Klamath as well as a salmon fishing site, and as such remains important in the cultural traditions of the Klamath Tribes. No known Native American archaeological sites are associated with this TCP. PacifiCorp proposes to improve fishing access along the lower portion of Big Bend with installation of parking, an ADA-accessible fishing access platform, and an improved access trail.

The Shasta Nation (Daniels, 2006) enumerates TCPs along the Klamath River from just below the J.C. Boyle powerhouse to Iron Gate dam. Eligible TCPs identified by the Shasta Nation include a number along the J.C. Boyle peaking reach, including the Frain Ranch area on both sides of the reach. Although PacifiCorp proposes no recreational improvements along the shorelines of the peaking reach, the Bureau of Land Management, in its modified 4(e) condition 6, specifies that locations such as Klamath River Campground, dispersed day-use sites, and Topsy Campground be included in PacifiCorp's Recreation Resource Management Plan and that measures be developed for maintenance and development of these locations for recreational use. Downstream, PacifiCorp proposes improvements to the river access point just below Iron Gate dam, which is adjacent to a traditional Shasta tobacco-gathering place.

To most Native peoples, the natural environment is inseparable from culture. Thus, natural elements are considered integral to many TCPs. The Klamath Riverscape embodies these considerations on a large scale, as it encompasses archaeological sites, locations of traditional subsistence and ceremonial activities, and associated natural environment of landforms, moving water, aquatic, and terrestrial resources.

Our Analysis

The decommissioning of East Side and West Side developments would end the Commission's jurisdiction over lands in which the Link River TCP is located, potentially removing all or portions of this TCP from the protection afforded by NHPA. Additionally, removal of hydroelectric facilities and re-grading could involve substantial ground disturbance by mechanical equipment that could inadvertently damage or destroy archaeological or other features that contribute to the significance of this TCP. In the event of decommissioning, the Commission would require PacifiCorp to include in its decommissioning plans provisions for resolution of any adverse effects, developed in consultation with the Oregon SHPO. This would also hold true for decommissioning of any other development in the project.

We would not anticipate that removal of Keno development from the licensed project would adversely affect the Miller Island Oxbow TCP, as that action would not involve any actions involving ground disturbance in that area, and the land containing the TCP would remain under federal and state ownership, managed by FWS and Oregon Fish & Wildlife.

Enhancement of fishing access along Big Bend near the J.C. Boyle powerhouse, as proposed by PacifiCorp, could increase opportunities for Native Americans to use a traditional fishing area. However, such opportunities would also be available to the public at large, and increased visitation could result in

inadvertent or purposeful damage or destruction of landforms and other resources at Big Bend that are associated with the TCP at this location.

As noted in the previous discussion, archaeologists described effects of vandalism, looting, and OHV use on sites in the river reaches, including the J.C. Boyle peaking reach. Increased public use of land at locations, including but not limited to the Frain Ranch area, that contain TCPs as well as archaeological materials would likely result in increased adverse effects on historic properties. Similarly, improvements to the river access point below Iron Gate dam, as proposed by PacifiCorp and recommended by Interior, would also be likely to increase adverse effects on a TCP at this location.

With respect to the Klamath Cultural Riverscape, our resource-specific analyses (sections 3.3.1, *Geology and Soils*, 3.3.2, *Water Resources*, 3.3.3, *Aquatic Resources*, and 3.3.4, *Terrestrial Resources*) show that project operations as proposed by PacifiCorp would continue to affect resources that contribute to the significance of the Klamath Cultural Riverscape. Fish species, in particular salmon, steelhead, lamprey, and sturgeon; Pacific giant salamander; crayfish; cottonwood; willow; and other plant and animal species continue to be vitally important to the tribes of the Klamath basin for sustenance, cultural, and religious reasons. Project operations which could affect water quality, water quantity, fish movement, and sedimentation could negatively affect the health and plentitude of fish, plant, and animal species that are integral features of the Klamath Cultural Riverscape.

Plants and wildlife that occur within the aquatic and riparian communities within the project are also affected by water quality and flow fluctuations. As discussed in section 3.3.4.2, *Terrestrial Resources*, project operations resulted in riparian encroachment and reduced willow reproduction. Willows, cottonwoods, Indian rhubarb, watercress, and wild turnips are all riparian species important to the Klamath tribes for food and basket making, amongst other uses. The measures proposed by PacifiCorp would improve riparian conditions, which would likely protect and enhance most riparian ethnobotanical resources. The proposed flows, however would be unlikely to enhance young willow shoots reproduction, which are required for basket making. Planting willow as part of the site restoration efforts, as well as implementing Interior's recommendation to develop a vegetation management plan to reestablish native vegetation that is suitable to tribal members for food, medicine, basket materials, cradles, art, and other cultural products would, however, result in improved availability of such ethnobotanical resources. Outside of project facilities, project transmission line rights-of-way, project roads, and upland species would not be affected by project operations.

3.3.9.2.2 Management of Cultural Resources

As part of its application, PacifiCorp drafted an HPMP (revised in March 2006 in response to Commission comments) describing the policies and procedures it proposes to follow to manage cultural resources in the project over the term of a new license. In this section we analyze key components of PacifiCorp's HPMP and also recommendations for cultural resource management from agencies.

Area of Potential Effects

In section 3.3.9.1.1 we provide the Advisory Council's definition of an APE, and describe the original and subsequent (March 2006) APE proposed by PacifiCorp as the geographic extent of its cultural resource management responsibilities under a new license. PacifiCorp's original APE was based on the existing project. PacifiCorp subsequently revised its proposed APE to reflect its proposal to decommission East Side and West Side developments and to remove Keno development from the project; PacifiCorp's currently proposed APE thus essentially conforms to PacifiCorp's proposed project boundary. The SHPOs, agencies, and tribes have not concurred with PacifiCorp's proposed APE.

Our Analysis

The issuance of a license to operate a hydroelectric project is considered a federal undertaking subject to section 106 of NHPA. In the licensing process, the Commission uses existing conditions as the baseline for its assessment of the effects of licensing. The minimum APE for hydroelectric project relicensing customarily encompasses all lands within an existing project boundary, as well as those areas outside the project boundary, regardless of ownership, in which continued operation of a project could affect cultural resources. PacifiCorp's originally proposed APE is generally consistent with this customary minimum APE. PacifiCorp's currently proposed APE, however, would exclude lands (including portions of the existing project) for which the Commission needs to consider the effects of the proposed decommissioning and removal from the licensed project on cultural resources.

Inclusion of land within an APE does not mean that an undertaking would affect any or all cultural resources within that area. An APE is a hypothetical construct intended to establish a geographic framework in which there is reasonable possibility that an undertaking could affect historic properties. The Advisory Council's regulations (36 CFR 800.16[d]) explicitly state that the APE "may be different for different kinds of effects caused by the undertaking." As such, the APE serves as a starting point for analyses that uses information about historic properties and the nature and scale of the undertaking to determine whether or not the undertaking would affect historic properties, and if so, which properties, in what ways, and to what degree and geographical extent. Once this determination is made, appropriate measures to resolve any adverse effects (through avoidance, minimization or mitigation), and the geographic area, or areas, in which such measures should be applied, can be identified.

We considered a wide range of available information to conclude that the APE for our analysis of the potential effects on historic properties arising from relicensing the Klamath Hydroelectric Project appropriately encompasses (1) the entirety of the APE as delineated by PacifiCorp in its October 2004 draft HPMP and (2) that portion of the Klamath river reach from Iron Gate dam to the mouth. We include the reach below Iron Gate dam largely based on our analysis (see section 3.3.1.2.3) of project effects on sediment transport and water quality, including microcystin toxin (see section 3.3.2.2.2., *Water Quality*). Our analysis of sediment transport concludes that project effects on sediment supply contribute to adverse effects on recruitment and maintenance of young riparian vegetation in the reach between Iron Gate dam and the Scott River. Riparian vegetation helps stabilize land on river shorelines. Adverse effects on this vegetation can result in destabilization of shoreline containing archaeological sites, thereby adversely affecting those sites. We also note that adverse effects on riparian vegetation may also be considered adverse effects on TCPs, specifically the Klamath Cultural Riverscape in which the totality of the natural environment is a contributing element. Our analysis of water quality concludes that microcystin toxin originating from project reservoirs adversely influences water quality, and thus the "habitat" of aquatic resources whose presence contributes to the significance of the Klamath Cultural Riverscape, to the mouth of the river. Because other water quality problems cannot, on the basis of existing information, reliably be attributed to the project at this time, we consider (see section 3.3.2.2.2) measures to monitor water quality well below Iron Gate dam.

The geographic area to be covered under a finalized HPMP would be determined by the terms and conditions under which the project is relicensed.

Treatment of Historic Project Facilities

In its HPMP, PacifiCorp has proposed a series of review procedures that include consultation with the appropriate SHPO, to evaluate and minimize adverse effects on historic project facilities. PacifiCorp also proposes to develop within 1 year of license issuance Historic Resource Maintenance Guidelines for use by staff responsible for repair and maintenance of historic project facilities.

Our Analysis

Development and implementation of Historic Building Maintenance Guidelines, as proposed by PacifiCorp, would ensure that significant characteristics of historic buildings and structures are not inadvertently damaged, inappropriately altered, or lost. When adverse effects on historic buildings or structures, such as alterations affecting their historical integrity or demolition, cannot be avoided, consultation with the SHPO as proposed by PacifiCorp in the "Review Procedures for Evaluating and Minimizing Adverse Effects on Historic Properties" appendix of its HPMP, would ensure that such adverse effects are resolved in a manner consistent with the requirements of section 106 of the NHPA.

Treatment of Archaeological Sites

A first step in treatment of archaeological resources is assessment of their existing condition and periodic monitoring thereafter to determine whether the condition of a given resource has changed, and if so, why. Monitoring may indicate that project operations do, or are likely to, adversely affect the condition of a resource. In that case, the next step is to develop and implement treatments to repair damage where possible, and prevent further deterioration or loss. Such treatments take into consideration the type and significance of the resource as well as the agent and extent of the effect. For archaeological sites and traditional cultural properties, stabilization, fencing or barriers to access, and redirection of activities away from resource locations are examples of common treatments. Resources that are stabilized remain in place, protected by vegetative or other coverings from further harm. Data recovery (removal of archaeological materials from a threatened site) is a treatment of last resort, to collect and preserve information from the site when the site cannot be preserved in place.

In its March 2006 HPMP, PacifiCorp developed an archaeological monitoring plan responding to major kinds of effects on National Register-eligible archaeological sites within its proposed APE. The plan has two separate but related operational components. The first is a plan to patrol archaeologically sensitive (and vulnerable) areas to monitor effects of public access (authorized and unauthorized) on archaeological resources. The patrol program would be developed and implemented in consultation with appropriate law enforcement officials, and would be coordinated with drawdown schedules, seasonal changes in public use, and observed threats such as illicit artifact collection.

The second component of this plan is an inspection program, conducted by professional archaeologists, to monitor conditions of sites in reservoir drawdown zones that are or may be affected by erosion. Annual inspection during the first 3 years of implementation would produce baseline information regarding site conditions and stability that would be used to reprioritize, if appropriate, frequency of inspection or further treatment.

PacifiCorp has prioritized these ongoing treatment measures depending upon site conditions and known threats. Priority 1 sites would be scheduled for monitoring and patrol every 4 months, Priority 2 sites every 8 months, and Priority 3 sites every 12 months, in all cases beginning within 6 months of license issuance. Results would be reviewed annually, and sites reprioritized as appropriate based on these results and also results of any further treatments (such as stabilization or capping).

As site conditions indicate, PacifiCorp would implement further treatment to protect threatened archaeological sites within its proposed APE. Schedules for implementation would be based on the priority assigned to each site. PacifiCorp's HPMP describes a wide variety of possible treatment measures. Measures to restrict access include closure of informal roads and tracks, and of informal recreational use sites; limitation of OHV use; modification or elimination of ranching activities; and closure of selected developed recreation areas immediately adjacent to or within a large, significant archaeological site. Other measures include capping sites with gravel, using native vegetation to conceal sites, and erecting signage that directs visitors away from sensitive areas. PacifiCorp has also identified several measures for erosion control at sites along reservoir shorelines, such as armoring with bulkheads

or revetments, installation of hay bales to deflect wave surges, and emplacement of geotextile fabric, gabions, or in-water wave booms.

Although PacifiCorp has not proposed any specific data recovery actions, it identifies site CA-SIS-2579 as a possible candidate for emergency data recovery if subsurface testing indicates that the site is eligible for the National Register. In the event that any data recovery actions are needed during the license term, PacifiCorp proposes to consult first with the SHPO and tribes. If the action is to occur on federal land, PacifiCorp assumes that the relevant federal land management agency would formally consult with the tribes and SHPO regarding the proposed investigation.

Pursuant to an ALJ order of August 16, 2006, PacifiCorp agreed to undertake detailed, site-specific archaeological investigations at five sites (35KL21/786, 35KL22, 35KL24, 35KL558, and 35KL577) located on the T-1 terrace in the J.C. Boyle peaking reach, in cooperation/consultation with the Bureau of Land Management to determine if PacifiCorp's flow operations are causing erosion.

The Bureau of Land Management specifies that PacifiCorp conduct archaeological survey on 77.2 acres of Bureau of Land Management land (delineated by the Bureau of Land Management as Units A through P) located within the APE as originally proposed by PacifiCorp that were not covered in PacifiCorp's pre-application surveys. These lands are located along the J.C. Boyle bypassed reach at Big Bend and along the J.C. Boyle peaking reach.

The Bureau of Land Management specifies that PacifiCorp revise its HPMP to specifically provide for monitoring and (as necessary) further treatment of archaeological sites on Bureau of Land Management land within the APE. The Bureau of Land Management also specifies that PacifiCorp include at least 20 percent of sites on Bureau of Land Management managed land in the APE in its annual site monitoring, and prepare an annual report to the tribes and the Bureau of Land Management regarding monitoring and other actions. PacifiCorp's alternative 4(e) conditions to the Bureau of Land Management's 4(e) conditions would limit the geographical scope of those measures to the Bureau of Land Management land within the project boundary as delineated in the new license.

Interior recommends that PacifiCorp develop and implement an erosion protection program within 1 year of license issuance, to protect and stabilize cultural resources affected by unauthorized OHV and other human causes. Interior also recommends that PacifiCorp's monitoring plan should be developed in consultation with the tribes and the Bureau of Indian Affairs and should include use of surveillance cameras and periodic patrols that include tribal staff equipped with communications equipment for notification of local law enforcement.

The Oregon SHPO recommends that PacifiCorp consult with the tribes, SHPO and appropriate land managers, and sign a Memorandum of Agreement, prior to capping any archaeological sites.

Our Analysis

PacifiCorp's proposed archaeological monitoring program provides appropriately differing approaches toward addressing the different effects caused by public access and shoreline erosion and determining the most appropriate ways to resolve those effects. Development and implementation of the patrolling program in consultation with appropriate law enforcement agencies should ensure that the roles and responsibilities of the patrol members are clearly and appropriately established, and that the methods and equipment used during patrols are appropriate for the task. Involvement of state and federal law enforcement organizations, as well as county officials, in development of the patrolling program would be appropriate given the amount of public land in or adjacent to the project. Efforts to include tribal members as part of the trained patrol staff, as recommended by Interior would enhance tribal involvement in protection and management of resources important in their traditions and cultures.

Consistent with Interior's recommendation, PacifiCorp's proposed archaeological inspection program includes provisions for close monitoring to determine the rates and variation of erosion at sites

along reservoir margins. This information would provide a basis for determining which treatment measures are appropriate for each site. The inspection program also provides for inspection of sites in the project that are damaged by other means, including OHVs, and the development and implementation of appropriate protective measures. Consistent with Oregon SHPO's recommendation PacifiCorp would consult with the tribes and SHPOs regarding protective site treatments (including data recovery, if necessary) on a case-by-case basis prior to implementation of any such treatment. Consultation with the appropriate federal land management agency would also be appropriate in the event that the affected site in question is on or immediately adjacent to federal land.

Concerning the Bureau of Land Management's 4(e) conditions and PacifiCorp's alternative conditions, regarding identification and treatment of archaeological sites on Bureau of Land Management land, we conclude that completing archaeological identification surveys within Bureau of Land Management units A through H, along the J.C. Boyle bypassed reach, and on those portions of Bureau of Land Management units I through P, lying within the geographic limits of project capacity in the J.C. Boyle peaking reach, would ensure that any significant archaeological sites in those locations that could be affected by project operations or project-related recreational enhancements would be appropriately treated. Consideration of recreational enhancements proposed by PacifiCorp for the area below J.C. Boyle dam has led us to conclude that archaeological surveys at Bureau of Land Management units along the bypassed reach would be appropriate.

Treatment of Traditional Cultural Properties

PacifiCorp has proposed no specific measures regarding the treatment of TCPs. However, in its draft HPMP, PacifiCorp proposes to provide the tribes with the opportunity to review and comment in advance of any proposed action, and to consult with the tribes, SHPOs, appropriate land management agencies, and the Commission in the event that a National Register-eligible TCP would be affected by such action.

The Shasta Nation's TCP study (Daniels, 2006), provides recommendations on a site-specific basis for treatment of TCPs described in that report. Recommended measures include limiting or prohibiting recreational access, relocation of activities away from sites, signage to warn against trespassing and provide information about laws protecting cultural resources, and in some instances, further archaeological investigations.

Our Analysis

TCPs (including cultural landscapes) can encompass a wide variety of resource types requiring very different kinds of management and protection. For example, archaeological data recovery of cultural materials associated with a TCP may not be appropriate, because the cultural materials may possess significance for reasons other than potential to yield important scientific information. The treatments recommended by the Shasta Nation for its TCPs speak to this issue and thus warrant consideration during consultations among PacifiCorp, the Tribes, the SHPOs, and agencies regarding treatment of cultural resources at risk from project operations. Other resource types within a TCP require different treatment. For example, a native plant species important to Native American culture and subsistence is dynamic, subject to its natural life cycles as well as conditions brought about by human and natural forces. Therefore, although individual plants cannot be "preserved in place" in the same manner as archaeological deposits in a TCP, external conditions can be modified, enhanced, or maintained to maintain environments conducive to the continuance of that plant species as a whole. Although PacifiCorp has proposed no measures specific to treatment of TCPs, in sections 3.3.1, *Geology and Soils*, 3.3.2, *Water Resources*, 3.3.3, *Aquatic Resources*, and 3.3.4, *Terrestrial Resources*, we describe and analyze proposed and recommended measures to address effects of project operations on such resources, and thereby, by extension, to address effects of project operations on TCPs consisting of or containing

such resources. Implementing such measures also would resolve many, if not all, existing project-related adverse effects on the various contributing elements associated with the Klamath Cultural Riverscape.

Other Cultural Resource Management Measures

PacifiCorp's draft HPMP includes a variety of other measures for management of cultural resources and implementation of the HPMP:

- Appointment of a historic properties coordinator responsible for overseeing implementation of the HPMP.
- Review of the HPMP every 3 years, with revision of the HPMP, as appropriate, based on previous years' results and experience, and on comments from the SHPOs and tribes; annual review of applicable state/federal laws to determine if there have been changes that require revision of the HPMP or changes to procedures; and annual contact with representatives of the tribes to discuss the status of historic properties management in the project and any potential changes to management measures.
- Annual training sessions for PacifiCorp staff that interact with the public or conduct activities potentially affecting historic properties. PacifiCorp would sponsor the attendance of a representative of the Klamath Tribes or the Shasta Tribe at each training session.
- Pre-action review by the historic properties coordinator of planned actions involving ground disturbance in accordance with procedures for review and consultation with SHPOs, appropriate tribes, and appropriate land management agencies specified in the HPMP.
- Development of public educational materials and programs that provide information about cultural resources, their significance, the need for their protection, and applicable laws, as part of PacifiCorp's proposed Interpretation and Education Plan.
- Implementation of specific protocols specified in the HPMP in the event of inadvertent discovery of a previously unknown cultural resource or human remains.
- Development and implementation, in consultation with the SHPOs and the Bureau of Land Management Klamath Falls and Redding Resource Offices, of guidelines meeting federal and state standards for curation of archaeological materials recovered in the project, including those owned by PacifiCorp that are temporarily in the possession of individual researchers and/or universities outside the Oregon/northern California region. Possible curation facilities to be considered are the museum at the Klamath Tribes' headquarters and the University of Oregon's Museum of Natural History.
- Confining implementation of the HPMP to resources and locations within PacifiCorp's proposed project boundary.

The Bureau of Land Management specifies that PacifiCorp consult with the Bureau of Land Management and the tribes every 5 years to determine whether the HPMP needs to be revised.

Interior recommends that PacifiCorp, in consultation with the tribes, SHPO and the Bureau of Indian Affairs, develop a vandalism awareness program to educate visitors and local area residents about legal and ethical implications of disturbing or destroying cultural sites. Interior also recommends that PacifiCorp develop a program to provide tribal members with access to traditional gathering areas, while at the same time limiting access by others.

Oregon SHPO recommends that the state Commission on Indian Services be contacted, along with the SHPO, state police, and tribes, in the event of discovery of human remains in Oregon.

Interior recommends that PacifiCorp invite tribal staff to participate in its annual emergency plan exercise and meeting. Interior also recommends that PacifiCorp allocate annual funding for tribal staff participation in cultural resource-related programs.

Our Analysis

PacifiCorp's proposals to appoint a historic properties coordinator with local knowledge of the project's cultural resources, familiarity with applicable state and federal laws and regulations, and professional experience in cultural resources management, and to review (and as appropriate, revise) the HPMP every 3 years would provide a sound basis for implementation of the HPMP over the license term. Review every 3 years would enable more timely revision of the document than would review every 5 years as specified by the Bureau of Land Management. PacifiCorp's proposal for annual discussion with the tribes on the status of overall cultural resources management would provide a regularly scheduled forum for tribal expression of views and recommendations about management of cultural resources. Affording appropriate federal land-management agencies the opportunity to comment, along with the SHPOs and tribes, on proposed revisions to the HPMP would ensure that federal agencies with interest in the management of cultural resources on or adjacent to their lands would be able to contribute their views.

PacifiCorp's proposal to conduct annual training sessions for staff involved with the public or involved in planning and implementation of actions potentially affecting significant cultural resources would ensure that new employees are educated in a timely manner. These sessions would also ensure that all employees are regularly informed about issues, procedures and protocols regarding cultural resource management in the project. Inviting the participation of a tribal representative at each training session would contribute toward staff understanding of Native American perspectives on cultural resources.

PacifiCorp's implementation review procedures during the planning of various actions, and protocols for inadvertent discovery of previously unknown cultural resources and human remains, as specified in its HPMP would ensure that significant cultural resources are not inadvertently harmed by project-related actions, and that resources and human remains would be appropriately treated. Including the Oregon State Commission on Indian Services in notification of any discoveries of human remains on lands of that state, as recommended by the Oregon SHPO, would enable the state to participate, as appropriate to its jurisdiction, in decisions regarding the treatment of those remains.

PacifiCorp's proposal to develop public information materials and programs about cultural resources, their significance, the need for their protection, and applicable laws as part of its larger Interpretation and Education Plan, would provide an effective vehicle for educating the public about vandalism, its effects, and its potential legal consequences.

PacifiCorp's proposal to develop and implement guidelines for curation of archaeological materials recovered in the project that are in accordance with federal and state requirements would ensure that such materials are properly conserved and also accessible, under properly controlled conditions, to those with appropriate research or cultural interests.

Native peoples continue to reside in the project area and carry on traditional practices that include the use of traditional plants. Efforts to protect locations where traditional plants occur and to provide access to these locations to members of the tribes, as recommended by Interior would assist with the continuation of traditional practices over the term of any license issued for the project.

Tribal participation in PacifiCorp's annual emergency plan exercise and meeting, as recommended by Interior, is not an issue for the Commission to consider in relicensing. The Commission's Portland Regional Office coordinates site-specific Emergency Action Plans, and would have information pertaining to these activities.

Financial support for tribal participation in measures related to cultural resources management in the project, as recommended by Interior, could potentially enhance the involvement of interested tribal members who might otherwise find it difficult to participate.

Commission staff intends to execute a programmatic agreement stipulating that PacifiCorp complete and file a final HPMP with the Commission within 1 year after license issuance. In the event of the decommissioning of portions of the existing project, the Commission would most likely require PacifiCorp to develop and implement one or more decommissioning plans. Such plans would specify measures by which the Commission would ensure that adverse effects on historic properties, as a result of removal of lands and resources from the protection afforded by federal jurisdiction, would be resolved.

3.3.9.3 Unavoidable Adverse Effects

Execution of the programmatic agreement and implementation of a finalized HPMP over the term of a new license would ensure management of significant cultural resources within the APE of the Klamath Hydroelectric Project. In addition, it would provide resolution of any unavoidable project-related adverse effects.

3.4 NO-ACTION ALTERNATIVE

Under the No-action Alternative as defined by the staff, the project would continue to operate as it is currently. There would be no significant change to the existing environmental setting or project operation. No new environmental measures would be implemented.

3.5 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Relicensing the existing project would not irreversibly or irretrievably commit any significant developmental or nondevelopmental resources in the Klamath River Basin. In the future, project facilities could be modified or removed and operations could be altered. No major new capacity or construction is proposed or recommended that would commit lands or resources in an irreversible manner.

3.6 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

PacifiCorp's Proposal for the project is expected to provide an average of 676,455 MWh of energy each year to the region. This long-term energy productivity would extend for at least as long as the duration of the new license. Our evaluations are designed to identify and then minimize or avoid long-term decreases in biological productivity of the system, as well as enhance aquatic habitat and local and regional recreational opportunities.

If the project were operated solely to maximize hydroelectric generation, there would be a loss of long-term productivity of the river fisheries due to decreases in water quality and fish habitat. Moreover, many efforts to enhance recreational opportunities at the project would be foregone.

With the proposed operating mode, as well as with proposed and recommended enhancement and protection measures, the project would continue to provide a low-cost, environmentally sound source of power. The project would further many of the goals and objectives identified by agencies, tribes, and other interested parties.