RUSSIAN RIVER BIOLOGICAL ASSESSMENT

INTERIM REPORT 7:
HYDROELECTRIC PROJECTS OPERATIONS

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
San Francisco District
San Francisco, California

and

SONOMA COUNTY WATER AGENCY
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Walnut Creek, California

August 18, 2000

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The Sonoma County Water Agency (SCWA) and the U.S. Army Corps of Engineers (USACE) are undertaking a Section 7 consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate effects of operations and maintenance activities on protected species and critical habitat. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, steelhead, and chinook salmon. The SCWA, USACE and Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFC&WCID) operate and maintain facilities and conduct activities related to flood control, channel maintenance, water diversion and storage, hydroelectric power generation, and fish production and passage.

As part of the Section 7 Consultation, USACE and SCWA will submit to NMFS a biological assessment (BA) that will provide the basis for NMFS to prepare a biological opinion (BO) that will evaluate project operations. The BA will integrate the Interim Reports on various project operations. This Interim Report addresses hydroelectric operations, including the Warm Springs Dam Hydroelectric Facility (WSD Hydroelectric Facility) located at Warm Springs Dam on Dry Creek and the Lake Mendocino Hydroelectric Power Plant (LMHPP) at Coyote Valley Dam on the East Fork Russian River near the city of Ukiah.

Hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam generate power from releases from Lake Sonoma and Lake Mendocino, respectively. Hydroelectric facility operations are incidental to water supply operations. Water is released from Coyote Valley and Warm Springs dams to meet water demand or flood control operations. Potential effects of reservoir releases are addressed in *Interim Report 1* (Flood Control Operations), *Interim Report 3* (Instream Flow Requirements) and *Interim Report 4* (Water Supply Operations). Maintenance activities for the hydroelectric project are coincident with the maintenance for flood control activities.

The potential effects on protected steelhead, coho salmon and chinook salmon in the Russian River basin that are discussed in this report are summarized as follows:

1) Dissolved gas supersaturation.
2) Introduction of predators.

Gas supersaturation, especially nitrogen, has been known to cause gas bubble disease in juvenile and adult fish below other hydroelectric facilities. Introduction of predators from the lake habitat of the reservoirs could affect juvenile salmonids.

The current operations at the hydroelectric facilities are not likely to adversely affect the listed fish species and are not likely to adversely affect the designated critical habitat of the listed fish species. Key findings to support this conclusion are noted as follows.

Dissolved Gas Supersaturation

Dissolved gas supersaturation can be a problem at some hydroelectric facilities where high concentrations of nitrogen are introduced to the water passing through the turbines due to pressure in the penstock and the action of the turbine. No evidence of gas supersaturation has been found at either facility.

Dissolved gas levels have been measured at the inlet to the Don Clausen Fish Hatchery and show gas levels at saturation (R. Gunter, pers. comm., January 18, 2000). It is likely that the gas levels would be restored to air saturation in riffles and runs immediately downstream of the dams. There have been no reports of stress or mortality in fish directly below the dams, at the hatchery or at the Coyote Valley Fish Facility (B. Cox, pers. comm., January 2000). There are no indications that operations of the hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam bring gas supersaturation levels to a harmful level for protected species.

Introduction of Predators

Reservoirs can provide ideal habitat for introduced and native predators for salmonids, particularly bass and Sacramento pikeminnow. As water is passed from the reservoir through the dam, predators from the reservoir may be entrained in the flow and transferred to downstream habitats. The hydroelectric operations may reduce the survival of predators passing through the dam. Thus hydroelectric operations may result in fewer predators being transferred than during water supply or flood control activities. While turbine mortality may reduce predator introduction, a review of studies that assess fish mortality through hydroelectric turbines indicates that some fish could survive passage through Francis-type turbines (Bell 1981). Passage of a few predators may be enough to establish populations below the dams.

Warm Springs Dam Hydroelectric Facility

The predators that could pass through the hydroelectric facilities are members of a warmwater fish community, but coldwater conditions are found below the dam. Although limited sampling data exist, the best available information suggests that large populations of predators are not present in Dry Creek. The effect of potential predator introduction would likely be low on coho and steelhead rearing occurring in the cooler reaches of Dry Creek.

While there is a possibility that predators could be introduced from the reservoir, they would most likely be concentrated in the warmer reaches of the Russian River. Predators may survive in the mainstem Russian River that could prey on migrating smolts, but predators were established there before the operations of the hydroelectric facility began. Therefore, predator introductions that may occur from operations of the WSD Hydroelectric Facility are not likely to increase the risk of predation on protected species. Operation of the turbines may reduce the risk of predation on protected species by decreasing the number of predators that may otherwise be passed.

Lake Mendocino Hydroelectric Power Plant

The LMHPP operates two Francis-type Axel Johnson turbines. It is possible that some predators, particularly those that are members of the warmwater communities, could pass through the turbines and establish themselves in the warmer reaches of the Russian River. However, predators were established in the mainstem of the Russian River before hydroelectric operations began. Therefore, passage of these predators due to the operations of the LMHPP is not likely to introduce the risk of predation on protected species.

Striped bass are stocked in Lake Mendocino and it is possible that they may escape into the stream. There are no self-sustaining populations of striped bass in the upper river. While the introduction of striped bass is possible from Lake Mendocino, limited fish passage and unsuitable spawning conditions in the upper river would restrict the establishment of a population of this predator. Furthermore, while striped bass have been found in the lower river, it is rare to find them below Coyote Valley Dam. Therefore the risk of increased predation on salmonids from passage of striped bass is likely to be low. Operation of the turbines may reduce the risk of predation on protected species by decreasing the number of predators that may otherwise be passed.

Synthesis of Effects

Current operations of the hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam have minimal effects on protected species and their habitat. As the hydroelectric facility operations do not control the level of releases from the dams, there are no effects from flow on habitat or fish stranding. Dissolved gas supersaturation has not been a problem at either dam. Predators could be introduced from the reservoirs through the hydroelectric facilities, but as they were already established in the warmer reaches of the river before hydroelectric operations began, their introduction is not likely to establish new populations. While the introduction of predatory striped bass is possible from Lake Mendocino, the risk of increased predation on salmonids is low. Operation of the turbines may result in fewer predators being transferred than during water supply or flood control activities. Hydroelectric facility operations at Warm Springs Dam and Coyote Valley Dam are not likely to adversely affect the listed fish species and are not likely to adversely affect the designated critical habitat of the listed fish species.

1.0 Introduction

1.1 Section 7 Consultation

The Sonoma County Water Agency (SCWA), the U.S. Army Corps of Engineers (USACE), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFC&WCID) are undertaking a Section 7 Consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate effects of operations and maintenance activities. The activities of the USACE , SCWA, and MCRRFC&WCID span the Russian River watershed from Coyote Valley Dam and Warm Springs Dam to the estuary, as well as some tributaries. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, chinook salmon and steelhead. The SCWA, USACE, and MCRRFC&WCID operate and maintain facilities and conduct activities related to flood control, water diversion and storage, hydroelectric power generation, and fish production and passage. The SCWA, USACE, and MCRRFC&WCID also are participants in a number of institutional agreements related to the fulfillment of their respective responsibilities.

Federal agencies such as the USACE are required under the ESA to consult with the Secretary of Commerce to insure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. The USACE, SCWA, and NMFS have entered into a Memorandum of Understanding (MOU) which establishes a framework for the consultation and conference required by the ESA with respect to the activities of the USACE, SCWA and MCRRFC&WCID that may directly or indirectly affect coho salmon, chinook salmon and steelhead in the Russian River. The MOU acknowledges the involvement of other agencies including: the California Department of Fish and Game (CDFG), the U.S. Fish and Wildlife Service (USFWS), the State Water Resources Control Board (SWRCB), the North Coast Regional Water Quality Control Board (RWQCB), the State Coastal Conservancy, and the Mendocino County Inland Water and Power Commission (MCIWPC).

1.2 Scope of the Biological Assessment

As part of the Section 7 Consultation, the USACE and SCWA will submit to NMFS a biological assessment (BA) that provides a description of the actions subject to consultation, including the facilities, operations, maintenance and existing conservation actions. The BA will describe existing conditions including information on hydrology, water quality, habitat conditions, and fish populations. The BA will provide the basis for NMFS to prepare a biological opinion (BO) that will evaluate the project, including conservation actions.

The BA will integrate a number of Interim Reports:

Report 1	Flood Control Operations
Report 2	Fish Facility Operations
Report 3	Instream Flow Requirements

Report 4	Water Supply and Diversion Facilities
Report 5	Channel Maintenance
Report 6	Restoration and Conservation Actions
Report 7	Hydroelectric Projects Operations
Report 8	Estuary Management Plan

This report evaluates the effects of current operations and maintenance of the hydroelectric facilities on listed species and critical habitat in the Russian River. The facilities evaluated include the WSD Hydroelectric Facility on Dry Creek and the LMHPP located on the East Fork Russian River near the city of Ukiah.

1.3 STATUS OF COHO SALMON, STEELHEAD AND CHINOOK SALMON IN THE RUSSIAN RIVER

The primary biological resources of concern within the project area are coho salmon, steelhead and chinook salmon. These species are each listed as threatened under the ESA. The pertinent Federal Register notices for these species are provided in Table 1-1. Coho salmon and steelhead are native Russian River species, although there have been many plantings from other river systems (CDFG 1991). It is uncertain whether chinook salmon used the Russian River historically (NMFS 1999). They have been stocked in the past, were not stocked in the last two years, but continue to reproduce in the watershed. The Central California Coast coho salmon Evolutionarily Significant Unit (ESU), which contains the Russian River, extends from Punta Gorda in northern California south to and including the San Lorenzo River in central California, and includes tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system. The Russian River is the largest drainage included in the Central California Coast steelhead ESU, which extends from the Russian River down the coast to Soquel Creek near Santa Cruz, California. The chinook salmon listing defined the population unit that contains the Russian River as the California Coastal ESU. This ESU encompasses the region from Cape Blanco in Oregon south to San Francisco Bay.

Critical habitat for each of these species within the Russian River is designated as the current estuarine and freshwater range of the species including “all waterways, substrate, and adjacent riparian zones.…” For each species, NMFS has specifically excluded areas above Warm Springs and Coyote Valley dams and within tribal lands.

Table 1-1 Federal Register Notices for the Salmonids of the Russian River

Species	Listing	Take Prohibitions	Critical Habitat
Coho Salmon	Vol. 61, No. 212, Pgs. 56138-56147 Oct. 31, 1996	Vol. 61, No. 212, Pgs. 56138-56147 Oct. 31, 1996	Vol. 64, No. 86, Pgs. 24049-24062 May 5, 1999
Steelhead	Vol. 62, No. 159, Pgs. 43937-43954 Aug. 18, 1997	Vol. 65, No. 132, Pgs. 42422-42481 July 10, 2000	Vol. 65, No. 32, Pgs. 7764-7787 February 16, 2000
Chinook Salmon	Vol. 64, No. 179, Pgs. 50394-50415 Sept. 16, 1999	Not yet issued	Vol. 65, No. 32, Pgs. 7764-7787 February 16, 2000

Life history descriptions for these species are provided in Sections 1.3.1 through 1.3.3 so that effects from project operations can be evaluated. All three species are anadromous, but steelhead may also exhibit a life history type that spends its entire life cycle in freshwater. These species migrate upstream from the ocean as adults and spawn in gravel substrate. Their eggs incubate for a short period, depending on water temperature, and generally hatch in the winter and spring. Juveniles spend varying amounts of time rearing in the streams and then migrate out to the ocean, completing the cycle. Details on life history, timing and habitat requirements are provided for each species.

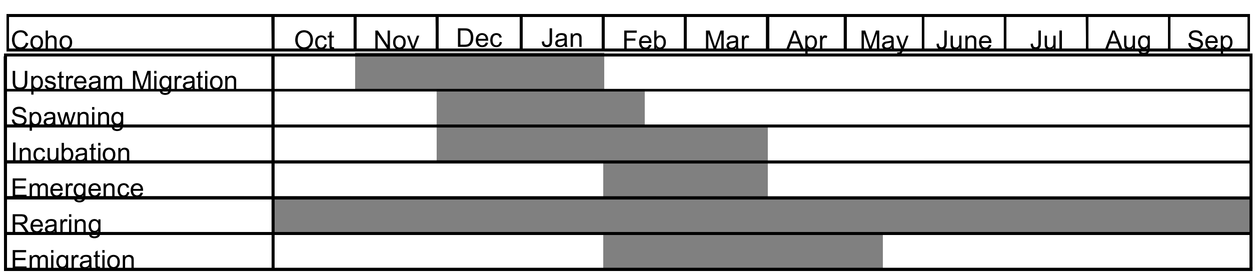
1.3.1 Coho Salmon

Coho salmon are much less abundant than steelhead in the Russian River basin. Spawning occurs in approximately 20 tributaries of the lower Russian River, including Dry Creek. In wet years, coho salmon have been seen as far upstream as Ukiah. The Don Clausen Fish Hatchery produces and releases an average of about 70,000 age 1+ coho salmon each year (1980-1998). However, no coho have been produced in the last two years.

1.3.1.1 Life History

The coho salmon life history is quite rigid, with a relatively fixed three-year life cycle. The best available information suggests that life history stages occur during times outlined in Figure 1-1 (EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999). Most coho enter the Russian River in November and December and spawn in December and January. Spawning and rearing occur in tributaries to the lower Russian River. The most upstream tributaries with coho salmon populations include Forsythe, Mariposa, Rocky, Fisher and Corral creeks. The mainstem below Cloverdale serves primarily as a passage corridor between the ocean and the tributary habitat.

After hatching, young coho will spend about one year in freshwater before becoming smolt and migrating to the ocean. Freshwater habitat requirements for coho rearing include adequate cover, food supply, and water temperatures. Primary habitat for coho includes pools with extensive cover. Outmigration takes place in late winter and spring. Coho salmon live in the ocean for about a year and a half, return as three-year-olds to spawn, and then die. The factors most limiting to juvenile coho production are high summer water temperatures, poor summer and winter habitat quality, and predation.



(EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Figure 1-1 Phenology of Coho Salmon in the Russian River Basin

1.3.2 STEELHEAD

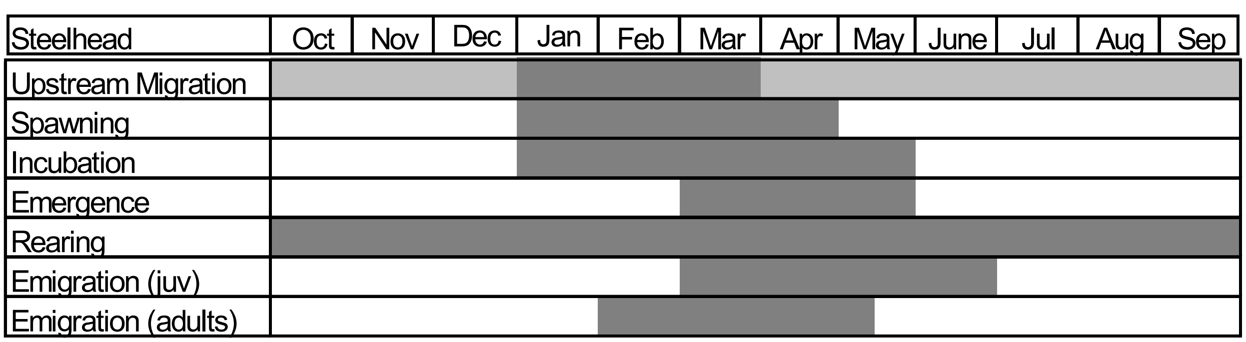
There have been no recent efforts to quantify steelhead populations in the Russian River, but there is general agreement that the population has declined in the last 30 years (CDFG 1984, 1991). SCWA, CDFG and NMFS are currently developing programs to monitor trends in salmonid populations within the designated critical habitat boundaries for the basin. There has been substantial planting of hatchery reared steelhead within the basin, which may have affected the genetic constitution of the remaining natural population. Almost all steelhead planted prior to 1980 were from out-of-basin stocks (Steiner 1996). Since 1982, stocking of hatchery reared steelhead has been limited to progeny of fish returning to the Don Clausen Fish Hatchery and the Coyote Valley Fish Facility.

Steelhead occupy all of the major tributaries and most of the smaller ones in the Russian River Watershed. Many of the minor tributaries may provide spawning or rearing habitat under specific hydrologic conditions. Steelhead use the lower and middle mainstem Russian River primarily for migration to and from spawning and nursery areas in the tributaries and the mainstem above Cloverdale. However, it is possible that juvenile rearing may occur in the mainstem before smolt outmigration. The majority of spawning and rearing habitat for steelhead occurs in the tributaries.

1.3.2.1 Life History

Adult steelhead generally begin returning to the Russian River in November or December, with the first heavy rains of the season, and continue to migrate upstream into March or April. They have been observed in the Russian River during all months (S. White, SCWA pers. comm. 1999). The peak migration period tends to be January through March (Figure 1-2). Flow conditions are suitable for upstream migration in most of the Russian River and larger tributaries during the majority of the spawning period in most years. Sandbars blocking the river mouth in some years may delay entry into the river. However, during the times the sand barrier is closed, the flow is probably too low and water temperature is too high to provide suitable conditions for migrating adults further up the river (CDFG 1991).

Most spawning takes place from January through April, depending on the time of freshwater entry (Figure 1-2). Steelhead spawn and rear in tributaries from Jenner Creek near the mouth, to



Note: Peak upstream migration occurs January through March, but adults have been observed in all months. (EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Figure 1-2 Phenology of Steelhead in the Russian River Basin

upper basin streams including Forsythe Creek, Maroposa, Rocky, Fisher and Corral creeks. Steelhead usually spawn in the tributaries, where fish ascend as high as flows allow (USACE 1982). Gravel and streamflow conditions suitable for spawning are prevalent in the Russian River mainstem and tributaries (Winzler and Kelly Consulting Engineers [Winzler and Kelly] 1978), although gravel mining and sedimentation have diminished gravel quality and quantity in many areas of the mainstem. In the lower and middle mainstem (below Cloverdale) and the lower reaches of tributaries, water temperatures exceed 55^{o}F by April in some years (Winzler and Kelly 1978), which may limit the survival of eggs and fry in these areas.

After hatching, steelhead spend from one to four years in freshwater. Fry and juvenile steelhead are extremely adaptable in their habitat selection. Requirements for steelhead rearing include adequate cover, food supply, and water temperatures. The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable habitat, as these areas generally have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing. The lower sections of the tributaries provide less cover, as the streams are often wide and shallow and have little riparian vegetation, and water temperatures are often too warm to support steelhead. In the summer, these areas can dry up completely. Available cover has been reduced in much of the mainstem and many tributaries because of loss of riparian vegetation and changes in stream morphology.

Emigration usually occurs between February and June, depending on flow and water temperatures (Figure 1-2). Sufficient flow is required to cue smolt downstream migration. Excessively high water temperatures in late spring may inhibit smoltification in late migrants.

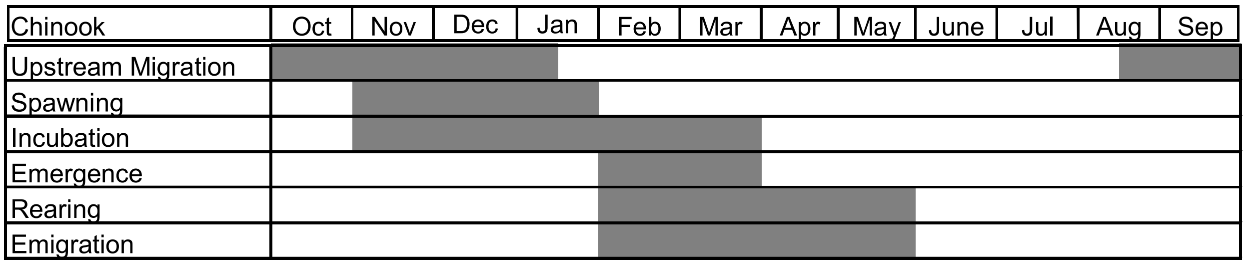
1.3.3 Chinook Salmon

The historic extent of naturally occurring chinook salmon in the Russian River is debated (NMFS 1999). Whether or not chinook were present historically, the total run of chinook salmon today, hatchery and natural combined, is small. Historic spawning distribution is unknown, but suitable habitat formerly existed in the upper mainstem and in low gradient tributaries. Chinook currently spawn in the mainstem and larger tributaries, including Dry Creek. Chinook tissue samples were collected this year by the SCWA and CDFG from Forsythe and Feliz creeks, and Dry Creek, and there were anecdotal reports of chinook in the Big Sulphur system.

1.3.3.1 Life History

Adult chinook salmon begin returning to the Russian River as early as August, with most spawning occurring after Thanksgiving. Chinook may continue to enter the river and spawn into January (Figure 1-3) (S. White, SCWA, pers. comm., 1999).

Unlike steelhead and coho, the young chinook begin their outmigration soon after emerging from the gravel. Freshwater residence, including outmigration, usually ranges from two to four months, but occasionally chinook juveniles will spend one year in fresh water. Chinook move downstream from February through May (Figure 1-3). Ocean residence can be from one to seven years, but most chinook return to the Russian River as two to four-year-old adults. Like coho salmon, chinook die soon after spawning.



(EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Figure 1-3 Phenology of Chinook Salmon in the Russian River Basin

1.4 PROPOSED PROJECT

1.4.1 WARM SPRINGS DAM HYDROELECTRIC FACILITY

1.4.1.1 Introduction and Location

WSD Hydroelectric Facility is located at the confluence of Warm Springs Creek and Dry Creek, approximately 14 miles northwest of Healdsburg, and approximately 12 ½ miles upstream from the confluence of Dry Creek and the Russian River. The WSD Hydroelectric Facility is located within the control structure of the outlet works for the Warm Springs Dam. Figure 1-4 shows the general location of the facility and Figure 1-5 shows a site-specific diagram of the facility.

The WSD Hydroelectric Facility is owned and operated by the Sonoma County Water Agency (SCWA). The Hydroelectric Facility was completed in December 1988 at a total cost of approximately $5 million. The SCWA operates the facility under a 50-year license issued by the FERC on December 18, 1984 (Project No. 3351-002).

1.4.1.2 Facilities

Water from Lake Sonoma is moved through the WSD Hydroelectric Facility to generate electricity. The equipment used to accomplish this consists of a generator, turbines, connector pipe, transformer substation, transmission lines, and appurtenances. The WSD Hydroelectric Facility is situated below ground at the base of the Warm Springs Dam control structure, which is housed in an approximately 300-foot deep, 30-foot diameter vertical shaft near the north abutment of the dam. The only visible part of the hydroelectric facility above ground is the transformer substation and connecting electrical power lines at the top of the control structure shaft. The WSD Hydroelectric Facility's generator has a power rating of 2.6 megawatts (MW).

Fish in Lake Sonoma may pass through the WSD Hydroelectric Facility, but the upstream movement of fish from Dry Creek to the facility is restricted by the design of the outlet structure. Water from Lake Sonoma flows to the hydraulic turbines via a vertical wet well located in the control structure that draws draw water from two horizontal low-flow tunnels positioned at two different elevations. Water from the tunnels drops between 132 and 221 feet to the turbines. The intake pipes are not screened and cannot prevent fish from Lake Sonoma from entering the turbines. Water passing through the turbines flows through a 2,047-foot long outlet pipe to one stilling basin, located at the base of the dam. From the stilling basin, water either flows through

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RUSSIAN RIVER WATERSHED
HYDROELECTRIC FACILITIES

FIGURE 1-4

WARM SPRINGS DAM HYDROELECTRIC FACILITY

FIGURE 1–5

a channelized portion of Dry Creek or is diverted for use in the Don Clausen Fish Hatchery at Warm Springs Dam. The stilling basin is a concrete lined basin at the mouth of the outlet pipe. A two-step weir, approximately 18-feet high, is used to reduce the water velocity from the outlet pipe and restrict fish downstream of the dam from entering the outlet pipe.

1.4.1.3 Operations

The WSD Hydroelectric Facility is in operation during normal releases of storage water through the low-flow tunnels and a wet well. A minimum flow of 100 cubic feet per second (cfs) is needed to operate the turbines. The maximum flow capacity for the Warm Springs facility's turbine is 175 cfs. During flood control operations, when releases from Warm Springs Dam exceed approximately 2,000 cfs prior to the EWSL being repaired and 3,000 cfs after repairs, flow through the wet well and turbine are shut off to prevent hydraulically unstable conditions from developing in the outlet piping. When water releases of greater than 300 cfs are required, service gates in the intake conduit, located beneath the dam, are opened and flows bypass the wet well and turbine. A minimum flow of 500 cfs is needed to operate the service gate. Also, flows of 185 cfs through the turbines can continue, with the remaining flow bypassed through the service gates. However, the total flow through the wet well and the service gate must be less than 3,000 cfs.

Power produced at the facility is sold to Pacific Gas and Electric (PG&E). Between 11 million and 15 million kilowatt-hours of power are produced annually. In addition to revenue for the energy generated, the SCWA also receives a "capacity payment" for the value of the power generation made available during the peak power demand season. In order for the SCWA to fulfill its obligations under its contract with PG&E, the SCWA must generate a constant minimum of 1.246 MW during June, July and August, which are the peak demand months for power consumption (Pacific Gas and Electric 1984). This contract will expire in the near future. Some short-term exceptions to this power requirement are allowed for circumstances beyond the SCWA's control. A 20-inch bypass line installed inside the conduit that was designed to provide water to the hatchery in the event of a gate failure can divert water through the hatchery and out to Dry Creek at a maximum flow capacity of about 25-28 cfs.

Flows through the WSD Hydroelectric Facility are determined by water supply needs and minimum instream flow requirements. The water supply needs and minimum instream flow requirements set by the SWRCB Decision 1610 (SWRCB 1986) are greater than the flows needed to meet the minimum power generation requirements. As the water supply demands of the SCWA and other water users downstream of Warm Springs Dam increase in the future (particularly during June, July, and August), it is anticipated that minimum power generation requirements will have no influence on streamflows.

The Russian River System model, developed by the SCWA, models flow in the Russian River basin based on minimum streamflow requirements and water supply demands (Flugum 1996). The model calculates the amount of power generated at model flows. Table 1-2 shows the power generated at model flows for the summer months of June, July and August for the years 1988 through 1995. These years encompass both normal and dry conditions. All of the modeled power values exceed the minimum 1.246 MW. Therefore, hydroelectric operations at Warm Springs Dam do not control flow.

Table 1-2 Power Generated at Russian River Model Flows under Decision 1610

The Russian River System model predicts the power generated for the months of June, July and August, given water supply and minimum instream flow needs.

Water Year	Power (MW)
1988	2.427
1989	2.750
1990	1.382
1991	1.594
1992	4.129
1993	3.437
1994	1.606
1995	3.721

Articles 33 and 34 of the SCWA's FERC license (FERC 1984) contain minimum release provisions for Warm Springs Dam[1]. Under the recommendation of the CDFG, Article 34 specifies that the "Licensee shall for the protection of fish spawning in Lake Sonoma, operate the Warm Springs Project such that the water surface elevation of Lake Sonoma fluctuates no more than two vertical feet between April 1 and June 15 of each year."

The wording of Article 34 initially presented some uncertainty in how the WSD Hydroelectric Facility was to be operated under the license, since other operating requirements, such as Decision 1610[2] minimum streamflows and the USACE flood control release criteria (USACE 1984 and 1986a) require changing the surface elevation of Lake Sonoma by more than two vertical feet between April 1 and June 15. During the application process, SCWA and CDFG agreed that water should not be released solely for electrical power production purposes when such releases would contribute to or cause surface fluctuations in Lake Sonoma to exceed two vertical feet per month between April 1 and June 15. The recitals in FERC's 1984 order which issued the license stated FERC's intention to incorporate this agreement into the license without modification. SCWA's interpretation of Article 34 is that surface water fluctuations resulting from releases solely for the purpose of power production between April 1 and June 15 are limited to two vertical feet per month, as agreed by SCWA and CDFG, and as intended in the FERC order. In a letter dated June 2, 1989, SCWA notified FERC of its interpretation. FERC has taken no exception to this interpretation.

The primary concern regarding the quality of water released from Warm Springs Dam is for its use in the Don Clausen Fish Hatchery at Warms Springs Dam. Water quality factors in discharged water, such as temperature, dissolved oxygen, and turbidity, are managed by mixing water from the two of the four low-flow tunnels that draw water from different levels of Lake Sonoma. The selection of water intake levels from Warm Springs Dam is determined by

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[1] Further details on water supply and minimum streamflow needs will be addressed in *Report 3: Instream Flow Requirements* and *Report 4: Water Supply and Diversion Facilities*.

[2] Decision 1610 was prepared by the SWRCB in April 1986 and amends the terms and conditions of water use permits held by the SCWA.

USACE in coordination with CDFG to meet the water quality needs of the fish hatchery. However, turbidity levels in the lower levels of the lake are too high to be used in the hatchery. The portal nearest to the lake's surface is out of service and therefore it is not used. Only the two intermediate portals are typically used to provide water for the hatchery and for downstream releases. This water passes through the hydroelectric facility before it reaches the hatchery. *Interim Report 2: Fish Facility Operations* has additional information on water use of the Don Clausen Fish Hatchery.

Because intakes to the WSD Hydroelectric Facilities are not screened, resident salmonids from Lake Sonoma could pass through the tunnels and into the turbines. To mitigate for potential fish losses from Lake Sonoma, additional enhancement measures were taken to improve the fishery of the Upper Russian River, which included expansion of the Don Clausen Fish Hatchery at Warm Springs Dam and construction of a fish facility at Coyote Valley Dam. Although the exact number of fish passing through the WSD Hydroelectric Facility's turbine is not known, it is expected that mortality occurs to fish passing through the turbine due to injuries either from mechanical blows or excessive pressure. Because the populations of coho salmon, chinook salmon and steelhead listed under the ESA are found below Warm Springs Dam, threatened species of fish are not drawn into the hydroelectric turbines.

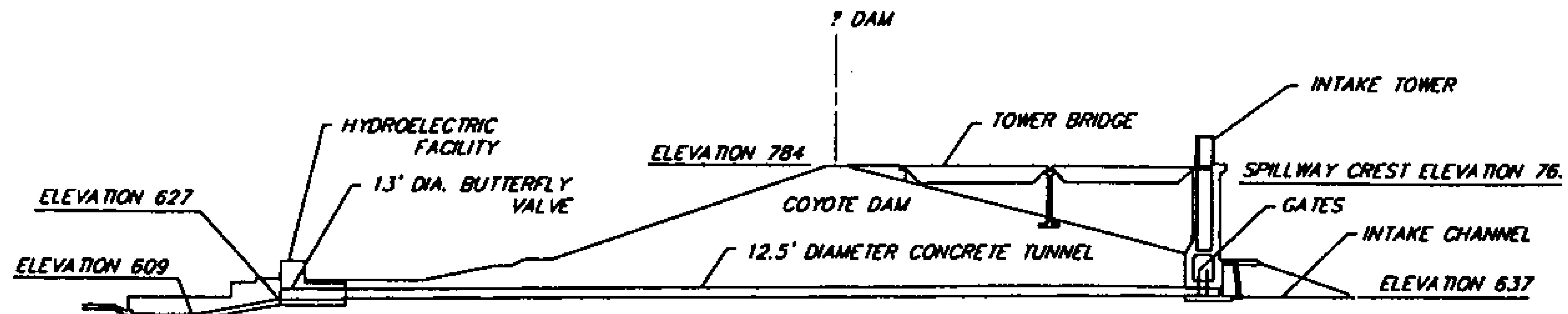
Warm Springs Dam operates a 3,000 KW Francis Turbine (USACE 1984). Fish in Lake Sonoma, including predators on salmonids, may pass through the WSD Hydroelectric Facility. A nonnative warmwater fishery exists in the reservoir and includes largemouth bass, smallmouth bass and redear sunfish. Steelhead became landlocked after construction of the dam. The Don Clausen Fish Hatchery did release excess production of rainbow trout into the reservoir during the first two years of operation. This practice was discontinued and trout have not been stocked since the mid-80's (B. Cox, CDFG, pers. comm., 2000). Pikeminnow were part of the native community and are self-sustaining in the reservoir. As Lake Sonoma becomes thermally stratified during the summer, dissolved oxygen in the hypolimnion is gradually depleted until little remains, and this excludes most fish species at these depths. The surface layer is generally about 30-35 feet deep (B. Cox, CDFG, pers. comm., 2000).

No instream work is necessary to maintain the WSD Hydroelectric Facility. All maintenance activities occur within the Warm Springs Dam control structure shaft. During any unplanned events that require shutting down the generator, automatic controls shut down flows to the turbine and open a valve which bypasses flows around the turbine unit.

1.4.2 Lake Mendocino Hydroelectric Power Plant

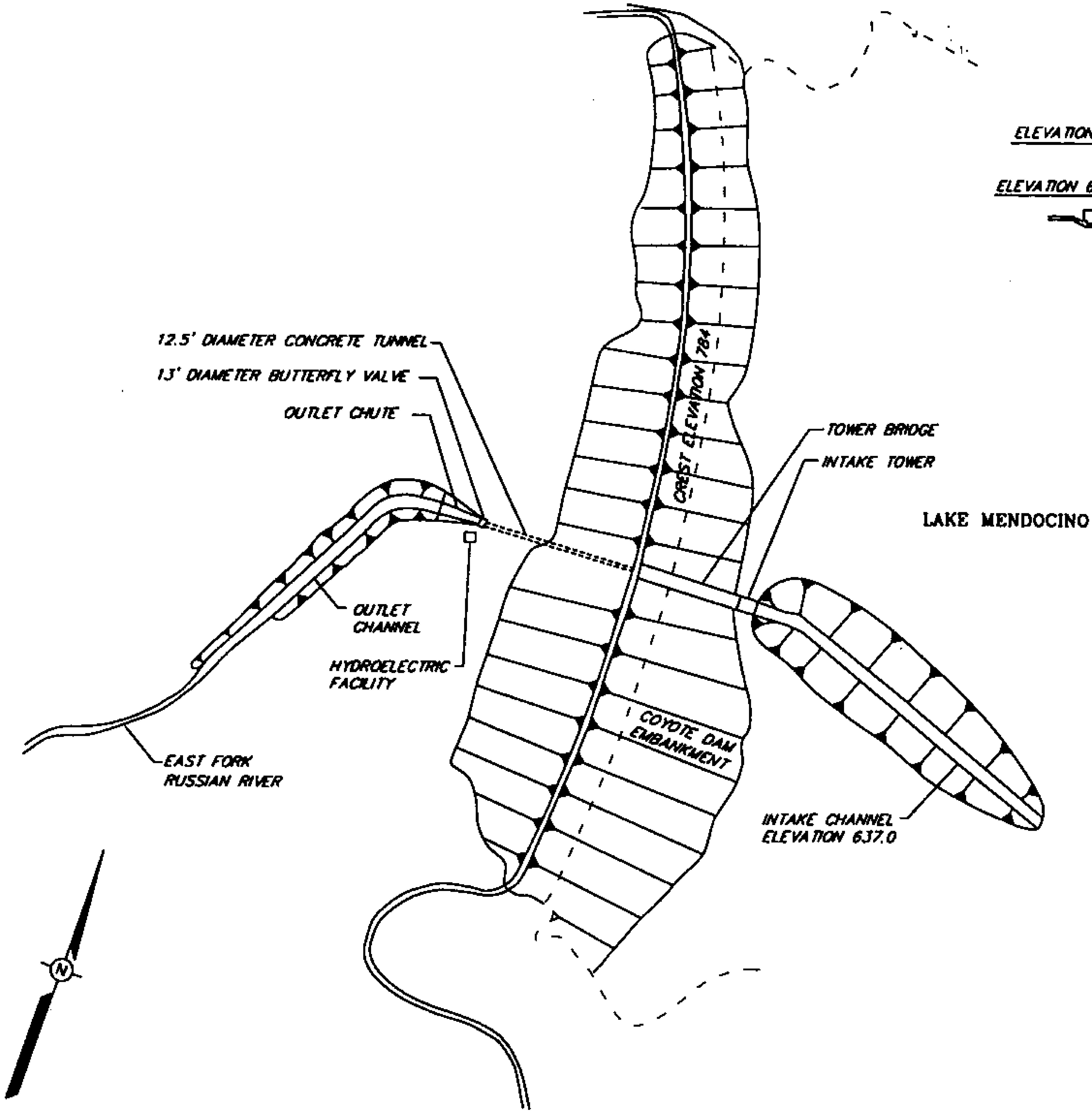
1.4.2.1 Introduction and Location

The LMHPP is located on the East Fork Russian River, 0.8 of a mile upstream from the confluence of the Russian River mainstem, and 3.2 miles northeast of the City of Ukiah. The project was completed in May of 1986 at a total cost of approximately $22 million. Coyote Valley Dam was completed in 1958 and was not originally designed to contain or supply a hydroelectric plant (City of Ukiah 1981). The LMHPP was added externally to the downstream base of the dam 28 years after the dam was built. Figure 1-4 shows the general location of the LMHPP. Figure 1-6 is a site location map of the facilities.



PROFILE VIEW

SCALE APPROXIMATELY 1" = 200'



PLAN VIEW

SCALE APPROXIMATELY 1" = 400'

SONOMA COUNTY WATER AGENCY

COYOTE VALLEY DAM HYDROELECTRIC FACILITY
PLAN AND PROFILE

FIGURE 1-6

The LMHPP is owned and operated by the City of Ukiah. The City of Ukiah operates the project under a 50-year license issued on April 1, 1982, by FERC (Project No. 2481-001). The City of Ukiah belongs to the Northern California Power Authority (NCPA). NCPA owns and operates various power generation plants throughout California and provides power to their members. The City of Ukiah uses the LMHPP to supplement other power sources within their system and has no contractual minimum power output requirements to maintain, and therefore has no right to control water releases. Power output is determined by the amount of water released from the dam for water supply, minimum instream flow requirements and flood control, rather than power generation needs. Releases from Coyote Valley Dam are regulated by USACE during flood control operations and by the SCWA for water supply.

1.4.2.2 Facilities

Water from Lake Mendocino is moved through the LMHPP to generate electricity. The equipment used to accomplish this consists of two turbines and associated generators, piping, valves, controls, and powerhouse structure. The two generators can produce 1 MW and 2.5 MW for a combined total of 3.5 MW.

Water flows are directed through the LMHPP from an outlet pipe, which consists of a 959-foot long, 12.5-foot diameter concrete pipe that extends beneath the dam between its upstream to downstream sides. Water flow rates into the LMHPP are regulated by tandem slidegates that are housed at the base of an inlet tower located at the entrance of the outlet pipe, and a butterfly valve located near the exit of the pipe. The slidegates and entrance to the outlet pipe are at an elevation of 637 feet mean sea level (msl), which is 169 feet above the spillway crest of the dam. Water flowing through the outlet pipe enters a rip rapped portion of the East Fork Russian River. A branch in the outlet pipe located upstream from the butterfly valve and at an elevation of 627.5 feet msl, diverts water from the main outlet pipe into the LMHPP. Flows exiting the facility run through a rip rapped channel that merges with the East Fork Russian River, approximately 700 feet downstream from the LMHPP.

1.4.2.3 Operations

The hydraulic turbines require flows between 175 and 400 cfs to operate and produce electrical power. Flows below 175 cfs are not sufficient to produce power. Dam flows, which pass through the facility, are maintained at a minimum of 25 cfs. All flow changes are controlled by the USACE as requested by the SCWA during the water supply season, and determined and controlled by the USACE during the flood season. The City of Ukiah has an agreement with FERC that is endorsed by CDFG and USFWS to provide between 7 cfs and 15 cfs of water to operate the fish facility at Coyote Valley Dam (FERC 1983). Minimum flow rates were specified for the hatchery facility in accordance with Decision 1610. The City of Ukiah has no control over the level of releases from the dam and is not currently operating the LMHPP due to minor damage to a diverter wall that controls flows to power plant turbines. The City of Ukiah is in the process of scheduling the needed repairs. When in operation, the LMHPP produces an average of eight to nine million kilowatt-hours of power annually.

FERC permit guidelines require the City of Ukiah to maintain dissolved oxygen levels downstream of their LMHPP at 7.5 milligrams per liter (mg/l) at least 90% of the time, with a minimum requirement of 7 mg/l, and a monthly median value of 10 mg/l for the year (FERC 1982). For five years as a back-up system, the City of Ukiah operated a liquid oxygen injection ring at their intake structure to assist in maintaining required oxygen levels when necessary while the turbines were in operation. In 1997, the City of Ukiah discontinued injection and removed the equipment after monitoring showed that the system was ineffective and the desired oxygen level is maintained from turbulence created by the water passing through the bypass valves in the piping system. When the turbines are in operation and the dissolved oxygen level approaches 7 mg/l, the turbines are shutdown and the flow diverted to the bypass valves. The City of Ukiah continuously monitors the dissolved oxygen level on a computer system.

Although the design of the LMHPP differs from the WSD Hydroelectric Facility, the potential effects on fish are similar for both facilities, including concerns for flow requirements and fish passing through the facility. As mentioned earlier, power output is determined by the amount of water released from the dam for water supply, minimum instream flow requirements and flood control. High and uniform flows through the outlet pipe from the hydraulic turbine restrict the upstream passage of fish into the LMHPP.

The inlet tower pipes are not screened to prevent fish in Lake Mendocino from entering the hydraulic turbines. Because the populations of coho salmon, steelhead, and chinook salmon listed under the federal ESA occur below Coyote Valley Dam, threatened salmonid species are not drawn into the hydroelectric turbines. To mitigate for potential fish losses, additional enhancement measures were taken to improve the fishery of the Upper Russian River, through the construction of a fish facility at Coyote Valley Dam and expansion of the Don Clausen Fish Hatchery at Warm Springs Dam. This involved the construction of new facilities below Coyote Valley Dam that consist of steelhead trapping facilities, holding, egg-taking, rearing and smolt imprint-release ponds. The licensee provides water to the ponds, including pumps, backup pumps, piping, power, backup power, maintenance, operation and replacement during the period of the license. Although the exact number of fish passing through the LMHPP's turbine is not known, it is expected that mortality occurs to all fish passing through the turbine due to injuries either from mechanical blows or excessive pressure.

The LMHPP operates two Francis-type Axel Johnson turbines. It is possible that fish in Lake Mendocino, including predators on salmonids, may pass through the hydroelectric facility.

LMHPP maintenance is accomplished without entering or altering the streambed because flows from the outlet pipe are diverted from the LMHPP before reaching the East Fork Russian River. The City of Ukiah provides personnel from their Water Operations Department to perform general preventative maintenance and light repairs. Major repairs are completed through the use of general contractors.

2.1 IDENTIFICATION OF POTENTIAL SPECIES AFFECTED

2.1.1 WARM SPRINGS DAM HYDROELECTRIC FACILITY

Coho salmon, chinook salmon and steelhead are present in Dry Creek downstream of Warm Springs Dam. Potential effects of hydroelectric operations at Warm Springs Dam on protected species and critical habitat in Dry Creek were evaluated.

2.1.2 LAKE MENDOCINO HYDROELECTRIC POWER PLANT

Chinook salmon and steelhead are present in the upper Russian River, and steelhead are present in the East Fork Russian River downstream of Coyote Valley Dam. The potential effects of LMHPP operations were evaluated in the East Fork Russian River.

2.2 POTENTIAL EFFECTS AND EVALUATION CRITERIA

Operation and maintenance activities at hydroelectric facilities generally affect streamflow through reservoir release, and water quality such as temperature, dissolved oxygen and dissolved nitrogen. At Coyote Valley and Warm Springs dams, hydroelectric operations are incidental to water supply and flood control operations and have no effect on streamflow or water temperature downstream of the facilities. Effects of reservoir operations are addressed in *Interim Report 1* (Flood Control Operations), *Interim Report 3* (Instream Flow Requirements) and *Interim Report 4* (Water Supply Operations). Maintenance activities for the hydroelectric project are coincident with the maintenance for flood control activities.

Potential effects of hydroelectric operations that are addressed in this report include:

1) Dissolved gas supersaturation.
2) Introduction of predators.

2.2.1 ISSUE OF CONCERN: DISSOLVED GAS SUPERSATURATION

Water absorbs gas up to a specific level at a given pressure, temperature and salinity. When air bubbles are under pressure in water, the water becomes supersaturated with dissolved gases (oxygen and nitrogen in particular). For example, when water moves down a spillway, it entrains air, and as the water falls into the plunge pool, it carries air bubbles deep into the water. The increase in pressure on these bubbles allows more gas to be transferred from the air to the water than it would have at surface water pressure. As air and water can be mixed and carried to substantial depths in a plunge basin of a spillway, hydrostatic pressures may increase the concentration of nitrogen in the water. Nitrogen supersaturation can occur at some hydroelectric facilities where high concentrations of nitrogen are introduced to the water passing through the turbines due to pressure in the penstock and the action of the turbine.

Fish living in supersaturated water can develop higher concentrations of nitrogen in their blood. At other facilities, this has caused gas bubble disease in fish, weakening or killing fish that are caught in shallow depths below the spill (NWFSC 2000). This is similar to the case where a scuba diver who has been breathing air at depth may develop “the bends” when he or she surfaces. Dissolved gas supersaturation has the potential to affect juveniles or adults.

Bell (1984) outlines lethal or damaging levels of nitrogen supersaturation on salmon as follows:

1)	Fry	103% of atmospheric and hydrostatic pressures
2)	Fingerlings and yearlings	113 (lethal)… 105-112% (eye damage and blindness)
3)	Adult	118% (eye damage)

The U.S. EPA (1976) has set an upper limit of 110% of saturation value for gasses at existing atmospheric and hydrostatic pressures to protect fish. If water does become supersaturated, dissolved gasses can be restored to air saturation levels. Gas can be removed by breaking up the water so that excess gas is released to the atmosphere (Bell 1990), as happens with turbulence.

Much work on the effects of gas supersaturation has been done in the Columbia and Snake rivers. Soon after Bonneville Dam was completed in 1938, dead adult salmon were found downstream. Dissolved gas supersaturation was documented and associated with spill at mainstem Columbia River dams by Ebel (1969, cited in NWFSC 2000).

Results of gas bubble disease monitoring and research on juvenile salmonids show that problems are associated with exceptionally high river flows and/or exceptional dam operation problems where powerhouse flows were limited in the Columbia River. Under high river flow conditions, total dissolved gas often cannot be kept below 120% (NWFSC 2000). High levels are common during the late spring and early summer due to increased spillway flow.

Models are being developed to predict the dissolved gas supersaturation levels below spillway plunge pools (Geldert *et al*. 1998, Dissolved Gas Abatement Study, USACE, Portland District). Dissolved gas levels are affected, among other factors, by the depth of entrainment of bubbles (related to depth of a stilling basin and river), the average flow velocity of a spill, turbulence in the stilling basin (related to the rate of energy loss), and the residence time of bubble in the flow. Dams with similar spillways can have very different dissolved gas supersaturation levels in their stilling basins (Darrin *et al.* 1998).

Potential dissolved gas supersaturation risks are assessed in this report by considering the factors that have increased the incidence of gas bubble disease at other facilities and whether these factors are at work with these two hydroelectric facilities. Because flows are not controlled by hydroelectric operations at either dam, hydroelectric operations do not increase dissolved gas levels by increasing the energy of outflows. The maximum flow capacity for the Warm Springs Facility’s turbine is 175 cfs, and this often represents only a portion of the total flow through the dam. There is no spill due to hydroelectric operations, and generally the spillway is not used even for flood control operations.

2.2.2 Issue of Concern: Introduction of Predators

Reservoirs are generally good habitat for fish species that are known to prey on salmonids. These reservoirs may serve as a source population from which downstream areas are colonized. Of particular concern are nonnative largemouth bass and smallmouth bass, green sunfish and native Sacramento pikeminnow. There are currently self-sustaining populations of these species in the Russian River (W.Cox, CDGG pers. comm. 2000). Striped bass have also been stocked in Lake Mendocino. As water is passed from the reservoir through the dam, predators from the reservoir may be entrained in the flow and transferred to downstream habitats. The hydroelectric operations may reduce the survival of predators passing through the dam. Thus hydroelectric operations may result in fewer predators being transferred than during water supply or flood control activities. While mortality due to turbine operation may reduce the number of predators passed, a review of studies that assess fish mortality through hydroelectric turbines indicates that some fish could survive passage through Francis-type turbines.

The two hydroelectric facilities are equipped with Francis turbines. Salmonid survival rates through Francis model turbines have been studied in the Columbia River basin (Bell 1981). Fish survival rate followed a general efficiency curve, with the highest survival occurring at the point of highest total efficiency of the turbine. Fish survival rates for all Francis turbines tested averaged over 60%. Mechanical losses in Francis turbines are related to the clearance between the wicket gates and the runners, and to runner size and speed. Larger fish in the wheels suffer greater mortalities. A factor not examined in these tests was the effect of the temperature on a fish in relation to the gas equilibration in its body. Fish forced from cooler depths to a warmer surface outlet and then subjected to pressure changes could be killed at an increased rate.

Several factors are considered in predation evaluation criteria. Structures that concentrate prey increase the potential for predation on protected species. If there are holding areas that favor predators near structures that concentrate salmonids, and if predators are actually present near those structures, protected species may be adversely affected. Only structures that provide predators access to areas that they have not historically reached would affect the level of predation. Furthermore, water temperatures favorable to predators would be needed.

To evaluate the risk of increased predation on protected species, three components were developed for predation evaluation criteria: structural criteria, access criteria, and habitat criteria (Table 2-2). Predator habitat criteria are based on water temperatures favorable to warm water predators, especially centrarchids and Sacramento pikeminnow. The optimum temperature for Sacramento pikeminnow is 26.3°C (Knight 1985). Warm water temperatures favor these predators at the same time that they negatively affect protected salmonids and their ability to avoid predation.

Table 2-1 Predation Evaluation Criteria

Category Score	Evaluation Criteria
	Component 1: Structural Criteria
5	No features that concentrate juvenile fish or provide cover for predators, concentrations of predators not found.
4	No features that concentrate juvenile fish, predator cover near, predators in low abundance locally.
3	Features that concentrate juvenile fish, no predator cover nearby, predators in medium to low abundance locally.
2	Features that concentrate juvenile fish, predator cover nearby, predators in medium to low abundance locally.
1	Features that highly concentrate juvenile fish, no predator cover nearby, predators abundant locally.
0	Features that highly concentrate juvenile fish, predator cover near concentration, predators abundant locally.
	Component 2: Access Criteria
5	Structure does not allow passage of predators, predators not present near structure.
4	Structure does not allow passage of predators, predators present near structure.
3	Structure provides limited passage of predators, predators not present near structure.
2	Structure provides limited passage of predators, predators present in limited numbers near structure.
1	Structure provides passage of predators, predators present in limited numbers near structure.
0	Structure provides passage of predators, predators present or migrate to structure.
	Component 3: Water Temperature Criteria for Warmwater Species
5	Water temperatures $< 13^{O}C$
4	Water temperatures 13 - $18^{O}C$
3	Water temperatures 18 - $20^{O}C$
2	Water temperatures 20 - $22^{O}C$
1	Water temperatures 22 - $24^{O}C$
0	Water temperatures $>= 24^{O}C$

3.1 DISSOLVED GAS SUPERSATURATION

One of the factors that has resulted in gas bubble disease at other facilities is entrainment of air in the plunge pool below the spillway. The spillways at Warm Springs Dam and Coyote Valley dam are not used. Water from the hydraulic turbines at Warm Springs Dam flows through a long outlet pipe to one stilling basin located at the base of the dam. A two-step weir, approximately 18 feet high, is used to reduce the water velocity from the outlet pipe. The difference in elevation from the outlet tunnel to the discharge channel is only 23.2 feet. At Coyote Valley Dam, water flowing through the outlet pipe of the dam is diverted into the hydroelectic facility near the exit of the pipe. Water is drawn through the outlet works from a relatively low elevation. Flow exiting the facility runs through a rip rapped channel that merges with the East Fork Russian River about 700 feet downstream from the LMHPP, and there is a fairly gentle gradient below the outlet of the dam.

Gas supersaturation can be a problem at some hydroelectric facilities where high concentrations of nitrogen are introduced into the water passing through the turbines due to pressure in the penstock and the action of the turbine. The amount of gas supersaturation that could occur from flow from the outlets or in the turbines has not been modeled for these facilities, but the configuration of the facilities do not suggest high risk factors that are found at other facilities. Furthermore, on the Columbia River, gas supersaturation of the water has increased from one dam to the next (Stull *et al*. 1987), but this is not a factor on the Russian River. There are no factors that concentrate protected species directly below the dam.

If adult (or juvenile) salmonids were to be found to have high stress or mortality levels, as they were in the Columbia River, this would be an indication that high levels of dissolved gas supersaturation could be present below the dam. Adult salmonids are routed to the fish facilities below each dam. There have been no reports of stress or mortality in fish directly below the dams (B. Cox, CDFG, pers. comm. January 2000).

Dissolved gas levels have been at saturation at the inlet to the Don Clausen Fish Hatchery (R. Gunter, pers. comm. January 18, 2000), which indicates gas supersaturation does not occur in the outflow of the dam. If saturation levels of nitrogen and oxygen levels were to increase, they could be expected to be restored to air saturation levels by turbulence in the discharge channel of the dam and in riffles and runs downstream of the facility.

Similarly, turbulence in the outlet channel of Coyote Valley Dam and in riffles and runs immediately downstream of the facility could be expected to help restore dissolved gas levels to air saturation levels. Furthermore, some of the outflow (between 7 to 15 cfs) from the dam is diverted to a degassing tower at the Coyote Valley Fish Facility that removes excess nitrogen and oxygen. The outflow from the fish facility would be expected to help maintain lower levels of dissolved nitrogen in the East Fork. There have been no reports of stress or mortality in salmonids at the Coyote Valley Fish Facility.

The lack of stressed or dead fish, the low levels of dissolved gases at the Don Clausen Fish Facility, and the lack of many of the factors that tend to contribute to dissolved gas supersaturation at other facilities, indicate that operations of the hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam do not bring gas supersaturation to harmful levels.

3.2 INTRODUCTION OF PREDATORS FROM THE RESERVOIRS

Reservoirs provide ideal habitat for introduced and native predators for salmonids. In the Russian River the primary predators are likely to be Sacramento pikeminnow and smallmouth bass (S. Chase, SCWA, pers. comm., 1999). Striped bass have been stocked in Lake Mendocino. Because passage through turbines is likely to result in substantial injury and mortality to predators, the risk of predator passage due to hydroelectric operations is reduced from what it would be for water supply or flood control operations.

3.2.1 WARM SPRINGS DAM HYDROELECTRIC FACILITY

A nonnative warmwater fishery exists in the reservoir and includes largemouth bass, smallmouth bass and redear sunfish. Pikeminnow have historically been part of the native community and are presently self-sustaining in the reservoir. Striped bass have not been stocked in the reservoir, and fortunately, there are no plans to stock them (B. Cox, CDFG June 14, 2000).

Lake Sonoma becomes thermally stratified during the summer. Dissolved oxygen in the hypolimnion is gradually depleted until little remains, and this would tend to exclude fish at deeper depths in the reservoir. The warm surface layer is generally about 30-35 feet deep (B. Cox, CDFG, pers. comm., 2000).

Fish in Lake Sonoma may pass through the WSD Hydroelectric Facility. Warm Springs Dam operates a 3,000 KW Francis turbine (USACE 1984). Salmonid survival rates through Francis model turbines have been studied in the Columbia River basin (Bell 1981). Fish survival rate followed a general efficiency curve, with the highest survival occurring at the point of highest total efficiency of the turbine. Salmonid survival rates for all Francis turbines tested were over 60%. While mortality to predatory fish can not be predicted from these studies, if it is possible for salmonids to survive it is also possible that some predatory fish may survive. Furthermore, as the hydroelectric facility does not control flow, the turbines may not always run at peak efficiency. It is expected that some number of predators would be injured or killed.

The first component of evaluation criteria for predation assesses the extent to which a structure concentrates prey in an area where predators are present (Table 3-1). The best available information suggests that salmonid juveniles are not concentrated directly below the dam. The hydroelectric facility itself would not concentrate salmonids below the dam. Predators are not known to be present in large numbers in Dry Creek, but they are present in the reservoir. Therefore, a score of 4 is given.

The second component assesses predation access. Although the number of fish passing through the turbine is not known, it is probable that mortality does occur to fish passing through the turbine. Because water is drawn from the deeper, cooler and less oxygenated depths of the reservoir, it is possible bass and pikeminnow are less likely to be entrained, at least during the summer months, when they occupy warmer surface water. Therefore, predator passage would be limited. The reservoir is not stratified during the winter. These predators are members of the warmwater fish community, but coldwater conditions are found below the dam. Although limited sampling data exist, it is not likely that large populations of predators would be present in Dry Creek. Allowing for the possibility of some limited predator passage, a score of 2 is given.

The third component assesses whether temperatures are suitable for predator habitat. Water temperatures at the outlet of Warm Springs Dam vary throughout the year from about 9-17°C. This would result in scores of 4 to 5 throughout the year. While there is a possibility that predators could be introduced from the reservoir, they would most likely be concentrated in the warmer reaches of the Russian River. Therefore the effect of predator introduction would probably be low on coho and steelhead rearing that occurs in the cooler reaches of Dry Creek. Introduction of predators that may survive in the mainstem Russian River could have an effect on steelhead and coho salmon migrating smolts, and possibly juvenile chinook salmon that may rear in the lower reaches of the river. However, predators were already established in the mainstem of the Russian River before hydroelectric operations began. Therefore, possible introduction of predators from the operations of the WSD Hydroelectric Facility is not likely to introduce a risk of predation on juvenile salmonids. Hydroelectric operations are likely to reduce the survival of predators passing through the dam, and thus fewer predators may be transferred than would be passed during water supply or flood control activities.

Table 3-1 Predation Evaluation Scores for Warm Springs Dam

Category Score	Evaluation Criteria	Current Operations Score*
	Component 1: Structural Criteria	
5	No features that concentrate juvenile fish or provide cover for predators, concentrations of predators not found.	
4	No features that concentrate juvenile fish, predator cover near, predators in low abundance locally.	WSD
3	Features that concentrate juvenile fish, no predator cover nearby, predators in medium to low abundance locally.	
2	Features that concentrate juvenile fish, predator cover nearby, predators in medium to low abundance locally.	
1	Features that highly concentrate juvenile fish, no predator cover nearby, predators abundant locally.	
0	Features that highly concentrate juvenile fish, predator cover near concentration, predators abundant locally.	

Table 3-2 Predation Evaluation Scores for Warm Springs Dam (continued)

	Component 2: Access Criteria	
5	Structure does not allow passage of predators, predators not present near structure.	
4	Structure does not allow passage of predators, predators present near structure.	
3	Structure provides limited passage of predators, predators not present near structure.	
2	Structure provides limited passage of predators, predators present in limited numbers near structure.	WSD
1	Structure provides passage of predators, predators present in limited numbers near structure.	
0	Structure provides passage of predators, predators present or migrate to structure.	
	Component 3: Water Temperature Criteria for Warmwater Species	
5	Water temperatures < 13^{O}C	WSD
4	Water temperatures 13 - 18^{O}C	WSD
3	Water temperatures 18 - 20^{O}C	
2	Water temperatures 20 - 22^{O}C	
1	Water temperatures 22 - 24^{O}C	
0	Water temperatures >= 24^{O}C	

*WSD = Warm Springs Dam

3.2.2 LAKE MENDOCINO HYDROELECTRIC POWER PLANT

The LMHPP operates two Francis-type Axel Johnson turbines. The inlet tower pipes are not screened to prevent fish in Lake Mendocino from entering the hydraulic turbines.

Coho and chinook are not thought to utilize the East Fork of the Russian River. The hydroelectric facilities do not concentrate juvenile steelhead, but predators are concentrated in the reservoir. Predator abundance data are not available for this area, but it is likely that the predators common to the warmwater communities are in the reservoir, as they are in Lake Sonoma. Additionally, striped bass are stocked on an irregular basis in Lake Mendocino, and they were stocked in 1999. It is possible some may escape into the stream. Striped bass also come into the Russian River from the ocean, and have been found in the lower river up to the Oddfellows Bridge upstream from Guerneville. Because no juveniles have been found in the river, it is not believed that they have spawned successfully. Although small striped bass were found at one time in Lake Mendocino, it is not believed that spawning is successful in the reservoir because adequate spawning conditions do not exist above the dam (B. Cox, CDFG June 14, 2000).

A score of 4 is given when applying the structural criteria (Table 3-2). The hydroelectric facility may allow limited passage for predators from the reservoir, so a score of 2 was given for the access criteria. Mean temperatures 500 feet below the dam for water years 1987-1997 (USGS gauge East Fork Russian River near Ukiah, CA, ID 11462000) varied from about 7 to 22ºC, with temperatures above 18ºC (scores of 2 and 3) generally occurring only between August and October. Temperatures could be suitable for pikeminnow during this time, and if this predator were present, it could affect rearing steelhead. As with the WSD Hydroelectric Facility, it is possible that predators could pass through the turbines and establish themselves in the warmer reaches of the mainstem Russian River. However the predators likely to be found in the warmwater communities are already present in the mainstem. Therefore, introduction of these predators from current operations of the LMHPP is not likely to introduce a risk of predation on protected species.

The potential for striped bass to escape from Lake Mendocino does exist. As there are no self-sustaining populations of striped bass in the upper river, introduction of this predator could contribute to an increase in predation on protected salmonids. There are two factors that may limit the passage of these fish. First, operation of the turbine would limit successful fish passage. Second, when the reservoir becomes stratified in the summer, low dissolved oxygen levels at the intake system of the dam near the bottom of the lake would make it unlikely that fish are passed through. While striped bass are sometimes found in the lower river, they are not generally found below Coyote Valley Dam. Although the potential does exist, the risk to protected species is likely to be very low. Predator mortality due to turbine operations is likely to reduce the number of predators that are passed.

Table 3-3 Predation Evaluation Scores for Coyote Valley Dam

Category Score	Evaluation Criteria	Current Operations Score*
	Component 1: Structural Criteria	
5	No features that concentrate juvenile fish or provide cover for predators, concentrations of predators not found.	
4	No features that concentrate juvenile fish, predator cover near, predators in low abundance locally.	CVD
3	Features that concentrate juvenile fish, no predator cover nearby, predators in medium to low abundance locally.	
2	Features that concentrate juvenile fish, predator cover nearby, predators in medium to low abundance locally.	
1	Features that highly concentrate juvenile fish, no predator cover nearby, predators abundant locally.	
0	Features that highly concentrate juvenile fish, predator cover near concentration, predators abundant locally.	
	Component 2: Access Criteria	
5	Structure does not allow passage of predators, predators not present near structure.	
4	Structure does not allow passage of predators, predators present near structure.	
3	Structure provides limited passage of predators, predators not present near structure.	
2	Structure provides limited passage of predators, predators present in limited numbers near structure.	CVD
1	Structure provides passage of predators, predators present in limited numbers near structure.	
0	Structure provides passage of predators, predators present or migrate to structure.	
	Component 3: Water Temperature Criteria for Warmwater Species	
5	Water temperatures < $13^{O}C$	CVD
4	Water temperatures 13 - $18^{O}C$	CVD
3	Water temperatures 18 - $20^{O}C$	CVD
2	Water temperatures 20 - $22^{O}C$	CVD
1	Water temperatures 22 - $24^{O}C$	
0	Water temperatures >= $24^{O}C$	

*CVD = Coyote Valley Dam

Hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam generate power from releases from Lake Sonoma and Lake Mendocino, respectively. Operation and maintenance activities at hydroelectric facilities generally affect streamflow through reservoir release, and water quality such as temperature, dissolved oxygen and dissolved nitrogen. At Coyote Valley and Warm Springs dams, hydroelectric operations are incidental to water supply and flood control operations and have no effect on streamflow or water temperature downstream of the facilities. Effects of reservoir operations are addressed in *Interim Report 1* (Flood Control Operations), *Interim Report 3* (Instream Flow Requirements) and *Interim Report 4* (Water Supply Operations). Maintenance activities for the hydroelectric project are coincident with the maintenance for flood control activities.

Gas supersaturation has been known to cause gas bubble disease in juvenile and adult fish below the spillway of other facilities. Introduction of predators from the lake habitat of the reservoirs could affect all lifestages of salmonids. The potential effects on protected coho salmon, steelhead and chinook salmon in the Russian River basin that are discussed in this report are summarized as follows:

1) Dissolved gas supersaturation.
2) Introduction of predators.

The current operations at the hydroelectric facilities are not likely to adversely affect the listed fish species and are not likely to adversely affect the designated critical habitat of the listed fish species. Key findings to support this conclusion are noted as follows.

4.1 DISSOLVED GAS SUPERSATURATION

Dissolved gas supersaturation (particularly nitrogen) can be caused by the entrainment of air bubbles in the water under pressure. High concentrations of nitrogen can be introduced to the water under the spillway of a dam, or when water passes through the turbines due to pressure in the penstock and the action of the turbine. The spillways of Warm Springs and Coyote Valley dams are not used.

Many of the factors that have resulted in dissolved gas supersaturation in other river basins are not at work in the Russian River. There have been no reports of stress or mortality in fish directly below the dams (B. Cox, pers. comm., January 2000). Dissolved gas levels have been at saturation at the inlet to the Don Clausen Fish Hatchery (R. Gunter, pers. comm., January 18, 2000). If saturation levels of nitrogen and oxygen levels were to increase, they would be expected to be restored to air saturation levels by turbulence in the discharge channels of the dams and in riffles and runs immediately downstream of the facility. Furthermore, some of the outflow from the dam is diverted to a degassing tower at the Coyote Valley Fish Facility that removes excess nitrogen and oxygen. There are no indications that operations of the hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam bring gas supersaturation to a harmful level for protected species.

4.2 INTRODUCTION OF PREDATORS

Reservoirs can provide ideal habitat for introduced and native predators for salmonids, particularly bass and Sacramento pikeminnow. Striped bass are also stocked in Lake Mendocino. Hydroelectric operations are likely to reduce the survival of predators passing through the dam. Thus hydroelectric operations may result in fewer predators being transferred than during water supply or flood control activities. While turbine mortality may reduce predator introduction, a review of studies that assess fish mortality through hydroelectric turbines indicates that some fish could survive passage through Francis-type turbines (Bell 1981). Passage of even a few fish could be enough to establish a population below the dams.

The risk of predation was evaluated with three components of the evaluation criteria: structural criteria, access criteria, and temperature criteria (Table 4-1). Reservoirs concentrate predators. Mortality would be expected for fish passing through the hydroelectric turbines, limiting passage, but some predators may survive. Finally, if warmwater habitat exists below the dam it would increase the probability that predators may be present.

Warm Springs Dam Hydroelectric Facility

The predators that could pass through the hydroelectric facilities are members of a warmwater fish community, but coldwater conditions are found below the dam. Although limited sampling data exist, it is not expected that large populations of predators would be present in Dry Creek.

While there is a possibility that predators could be introduced from the reservoir, they would most likely be concentrated in the warmer reaches of the Russian River. The effect of predator introduction would probably be low on coho and steelhead rearing occurring in the cooler reaches of Dry Creek. While predators may survive in the mainstem Russian River where could prey on migrating smolts, predators were established there before the operations of the hydroelectric facility began. Therefore, predator introductions that may occur from operations of the WSD Hydroelectric Facility are not likely to introduce predation on protected species.

Lake Mendocino Hydroelectric Power Plant

The LMHPP operates two Francis-type Axel Johnson turbines. It is possible that some predators could pass through the turbines and establish themselves in the warmer reaches of the Russian River. However, predators have been established in the mainstem of the Russian River. Therefore, passage of predators due to the operations of the LMHPP is not likely to introduce predation on protected species.

It is also possible that striped bass may be introduced into the upper river from Lake Mendocino. Spawning conditions for striped bass are not suitable in the upper river, and a self-sustaining population of this predator does not exist, so introduction of striped bass has the potential to increase predation on salmonids. However, difficult passage conditions at the dam, and the fact that striped bass are rarely found below the dam suggest the risk is very low.

Table 4-1 Predation Evaluation Scores

Category Score	Evaluation Criteria	Current Operations Score*
	Component 1: Structural Criteria	
5	No features that concentrate juvenile fish or provide cover for predators, concentrations of predators not found.	
4	No features that concentrate juvenile fish, predator cover near, predators in low abundance locally.	WSD CVD
3	Features that concentrate juvenile fish, no predator cover nearby, predators in medium to low abundance locally.	
2	Features that concentrate juvenile fish, predator cover nearby, predators in medium to low abundance locally.	
1	Features that highly concentrate juvenile fish, no predator cover nearby, predators abundant locally.	
0	Features that highly concentrate juvenile fish, predator cover near concentration, predators abundant locally.	
	Component 2: Access Criteria	
5	Structure does not allow passage of predators, predators not present near structure.	
4	Structure does not allow passage of predators, predators present near structure.	
3	Structure provides limited passage of predators, predators not present near structure.	
2	Structure provides limited passage of predators, predators present in limited numbers near structure.	WSD CVD
1	Structure provides passage of predators, predators present in limited numbers near structure.	
0	Structure provides passage of predators, predators present or migrate to structure.	
	Component 3: Temperature Criteria	
5	Water temperatures $< 13^{O}C$	WSD, CVD
4	Water temperatures 13 - $18^{O}C$	WSD, CVD
3	Water temperatures 18 - $20^{O}C$	CVD
2	Water temperatures 20 - $22^{O}C$	CVD
1	Water temperatures 22 - $24^{O}C$	
0	Water temperatures $>= 24^{O}C$	

*WSD = Warm Springs Dam, CVD = Coyote Valley Dam

4.3 SYNTHESIS OF EFFECTS

Current operations of the hydroelectric facilities at Warm Springs Dam and Coyote Valley Dam have minimal effects on protected species and their critical habitat. As hydroelectric facility operations do not control the level of releases from the dams, there are no effects from flow on habitat or fish stranding. There is nothing to indicate that dissolved gas supersaturation has been a problem at either dam. Predators could be introduced from the reservoirs through the hydroelectric facilities, but passage through the turbines is likely to reduce their survival rate. Thus hydroelectric operations may result in fewer predators being transferred than during water supply or flood control activities. As predators were already established in the warmer reaches of the river before hydroelectric operations began, their introduction is not likely to introduce the risk of predation on protected salmonids. While the introduction of predatory striped bass is possible from Lake Mendocino, the risk of increased predation on salmonids is low. Hydroelectric facility operations at Warm Springs Dam and Coyote Valley Dam are not likely to adversely affect the listed fish species and are not likely to adversely affect the designated critical habitat of the listed fish species.

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