State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
EVALUATION OF POTENTIAL EFFECTS OF FISHERIES MANAGEMENT ACTIVITIES ON ESA-LISTED FISH SPECIES
SP-F5/7 TASK 1

Oroville Facilities Relicensing
FERC Project No. 2100

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REPORT SUMMARY

To complete Task 1 of SP-F5/7, fisheries management activities were divided into two components; stocking related activities, and non-stocking related activities. Once these activities were summarized, a literature review was conducted to determine potential effects of fisheries management activities on fish species listed under the Endangered Species Act (ESA) and listed by the California Department of Fish and Game (DFG) as fish Species of Special Concern (SSC) downstream from the project in the Feather River.

Current fish stocking practices in the project area include the stocking of catchable sized brook trout and rainbow trout in the Thermalito Forebay and the stocking of coho salmon in Lake Oroville (DWR 2001; DWR 2003b). Potential interactions between stocked fish and fish species of concern in the project area and downstream from the project include competition, predation, disease transmission, and genetic introgression.

An examination of available reports indicates that few stocked fish escape from the reservoirs in which they are planted. A review of the literature on competition and predation with emphasis on the species involved in project operations indicates that the potential for competitive or predatory interactions with fish species of concern in the Feather River are minimal. In addition, current stocking practices minimize the likelihood of significant emigration of stocked fish from the reservoirs. For example, only catchable size fish are stocked in the Thermalito Forebay, and the stocking protocols for coho salmon in Lake Oroville are designed to minimize the stocking of fingerlings during the spring when higher flows may cause significant numbers of fish to escape the reservoir over the spillway.

The transmission of disease from hatchery fish to wild fish populations is often cited as a concern in fish stocking programs. There is, however, little evidence of disease transmission between hatchery fish and wild fish (Perry 1995). Normal hatchery operating procedures such as periodic examinations of on-station fish by fish pathologists, and disinfecting procedures are designed to control disease in hatchery stocks. The Feather River Hatchery has implemented disease control procedures that minimize both the outbreak of disease in the hatchery and the possibility of disease transmission to wild fish populations.

A review of available literature suggests two possibilities for genetic introgression among stocked salmonids and salmonids of concern in the Feather River. The first of these possibilities is intra-specific hybridization between coho salmon and Chinook salmon. Evidence of hybridization between these two species is weak. Additionally, there are no documented cases of fertile offspring as a result of coho salmon and Chinook salmon hybridization (Bartley et al. 1990). Coho salmon stocking protocols are designed to minimize the emigration of coho salmon from Lake Oroville so that the potential for hybridization is minimized.

The second possibility for genetic introgression of stocked salmonids and wild special status species is between stocked rainbow trout from the Thermalito Forebay and wild steelhead in the Feather River. A review of current stocking practices, combined with available information on wild steelhead spawning distributions, indicate that the possibility of stocked rainbow trout mating with wild steelhead is not a likely scenario. Additionally, those few spawning events that may occur are not likely to impact the overall genetic make-up of the wild steelhead population (Leary et al. 1995).

Non-stocking management activities in the project area are confined to Lake Oroville and specifically target the warm water fishery. The management activities in Lake Oroville include construction of habitat structures providing cover for juvenile black bass and the construction of catfish spawning structures. There have also been some activities promoting growth and longevity of warm water sport fish that involve genetic enhancements to the populations, such as the stocking of Florida strain largemouth bass, which was implemented to enhance the bass fishery in Lake Oroville. It is unlikely that these activities would impact special status fish species in the Feather River.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities has the potential to influence fish species listed under the federal Endangered Species Act (ESA) and fish species listed by the California Department of Fish and Game (DFG) as fish Species of Special Concern (SSC) in the DFG publication "*Fish Species of Special Concern in California*" (Moyle et al. 1995). Operations of the Oroville Facilities affect fisheries management activities occurring within the study area and fisheries management activities occurring within the study area, have the potential to influence ESA- and SSC-listed fish species by providing opportunities for interaction between fish species which otherwise may not have occurred. As a component of study plan (SP)-F5/7, *Evaluation of Fisheries Management on Project Fisheries,* Task 1 of SP-F5/7 identifies and characterizes the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species. For the purpose of Task 1, management activities taking place within the study area were divided into two components. The first component evaluates the potential effects of stocking-related sport fish management activities on ESA- and SSC-listed fish species in the Feather River. The second component evaluates the potential effects of non-stocking related sport fish management activities, such as habitat restoration and genetic enhancements to existing warmwater fish stocks to promote trophy fish production, on ESA- and SSC-listed fish species in the Feather River. ESA- and SSC-listed fish species in the study area are listed in Table 1.1-1.

Table 1.1-1. California Department of Fish and Game fish species of concern and ESA-listed fish species in the study area.

Species	Run/ Common Name	Status
Oncorhynchus tshawytscha	Spring-run Chinook Salmon	ESA – Threatened, Ca. Endangered
Oncorhynchus tshawytscha	Fall-run Chinook Salmon	ESA – Candidate, Ca. Special Concern
Oncorhynchus mykiss	Winter Steelhead	ESA - Threatened, Ca. Endangered
Acipenser medirostris	Green Sturgeon	ESA - Candidate, Ca. Threatened
Lampetra ayresi	River Lamprey	Ca. Watch List
Mylopharodon conocephalus	Hardhead	Ca. Watch List
Pogonichthys macrolepidotus	Sacramento Splittail	Ca. Threatened

Source: (Moyle et al. 1995; NOAA 1998; NOAA 1999).

1.1.1 Statutory/Regulatory Requirements

The purpose of SP-F5/7 Task 1 is to identify and characterize the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species. Salmonids present in the study area include spring-run Chinook salmon (*Oncorhynchus tshawytscha*), fall-run Chinook salmon (*O. tshawytscha*), and steelhead (*O. mykiss*). The Fish and Game Commission (California) formally listed spring-run Chinook salmon as a threatened species on February 5, 1999. On September 16, 1999, the Central Valley spring-run Chinook salmon ESU was listed as Threatened under the federal ESA by National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) (NOAA 1999). The Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU) includes all naturally-spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes the naturally-spawned spring-run Chinook salmon in the lower Feather River (NOAA 1999). In the same ruling, NOAA Fisheries determined that naturally-spawned Central Valley fall-run Chinook salmon were not warranted for listing under the federal ESA (NOAA 1999). However, the Central Valley fall-run Chinook salmon ESU was designated as a candidate for listing (NOAA 1999). The Central Valley fall-run Chinook salmon ESU includes all naturally-spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin River basins and their tributaries, which includes naturally-spawned fall-run Chinook salmon in the lower Feather River (NOAA 1999). On March 19, 1998, naturally-spawned Central Valley steelhead was listed as Threatened under the federal ESA by NOAA Fisheries (NOAA 1998). The Central Valley steelhead ESU includes all naturally-spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries residing below naturally formed and artificial impassable barriers (e.g., waterfalls and dams), which includes the naturally-spawned steelhead in the Feather River (NOAA 1998).

Green Sturgeon (*Acipenser medirostris*) was designated a California SSC by DFG in 1995 (Moyle et al. 1995). The DFG's SSC status applies to animals not listed under the federal ESA or the California ESA, but which nonetheless: 1) are declining at a rate that could result in listing; or 2) historically occurred in low numbers and known threats to their persistence currently exist. Species of Special Concern are categorized into one of 4 classes: Class 1 - Endangered or Threatened; Class 2 - Special Concern; Class 3 - Watch List; and Class 4 - Secure. Green sturgeon are listed as a Class 1 Threatened species, meaning that there should be ongoing efforts to protect and enhance this fish population (Moyle et al. 1995). Although not currently listed under the federal ESA, the green sturgeon was recently considered for listing under the federal ESA by NOAA Fisheries. On June 12, 2001, NOAA Fisheries received a petition from the Environmental Protection Information Center, Center for Biological Diversity, and Waterkeepers Northern California regarding the North American green sturgeon, in which the petitioners requested that NOAA Fisheries list this species as either an endangered or threatened species under the ESA (Environmental Protection Information Center et al. 2001). On January 29, 2003, NOAA Fisheries announced its determination that listing green sturgeon under the ESA was not warranted at the time (Federal Register, Vol. 68, No. 19, January 29, 2003, pg. 4433-4441). Because of remaining uncertainties about the population structure and status of the species, green sturgeon was added to NOAA Fisheries' list of candidate species. NOAA Fisheries will re-evaluate their status in 5 years provided sufficient new information becomes available indicating that a status review update is warranted.

In June 1995, river lamprey (*Lampetra ayresi*) was designated as a California SSC by the DFG (Moyle et al. 1995). The hardhead (*Mylopharodon conocephalus*) also was designated a SSC by DFG in 1995 (Moyle et al. 1995). River lamprey and hardhead are both listed as Class 3 Watch List species, meaning that they occupy much of their native range, but were formerly more widespread or abundant within that range (Moyle et al. 1995).

On February 8, 1999, Sacramento splittail (*Pogonichthys macrolepidotus)* was designated as Threatened under the ESA by the U.S. Fish and Wildlife Services (USFWS) (USFWS 2003). Splittail was listed as Threatened throughout its entire range, which includes the Feather River (USFWS 2003). On September 22, 2003, the USFWS issued a Notice of Remanded Determination for the Sacramento Splittail. This removed the Sacramento Splittail from the Endangered Species List. The fish is, however, still considered a SSC with a threatened status by DFG.

The results and recommendations from this study fulfill, in part, statutory and regulatory requirements mandated by the ESA as it pertains to Central Valley spring-run Chinook salmon, fall-run Chinook salmon, and steelhead. In addition to the ESA and California SSC, Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project. The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations. SP-F5/7 is designed to address potential effects associated with fisheries management activities in the project area.

This task is additionally related to the FERC Relicensing of the Oroville Facilities because FERC has a long history of fish stocking in Lake Oroville and the Thermalito Forebay. In 1977, FERC approved the California Department of Water Resources' (DWR) Oroville Facilities Recreation plan entitled Bulletin No. 117-6 (Oroville Reservoir, Thermalito Forebay, and Thermalito Afterbay Water Resources Recreation Report), which provided plans for public utilization of project lands and waters for recreational purposes through the year 2017 (FERC 1994). In 1994, FERC became additionally involved in fish stocking by requiring DWR to formulate and implement a fisheries management plan that would promote a multispecies warmwater and coldwater fishery with the general goal of benefiting a diverse angling community in Lake Oroville (FERC 1994), as further detailed in section 1.1.2.2, History.

As a subtask of SP-F5/7, *Evaluation of Fisheries Management on Project Fisheries*, Task 1, herein, fulfills a portion of the FERC application requirements by identifying and characterizing fisheries management activities that may affect fish species of concern in the Feather River. In addition to fulfilling these requirements, information developed in this study plan may also be used in determining appropriate protection, mitigation and enhancement (PM&E) measures or other management actions for the project.

1.1.2 Study Area

The study area encompasses Lake Oroville, its upstream tributaries, the Thermalito Complex, and the lower Feather River. The upstream tributaries of Lake Oroville consist of four major tributaries: the North Fork Feather River, the West Branch of the North Fork Feather River, the Middle Fork Feather River, and the South Fork Feather River. The upstream extent of the study area extends to the first stream channel obstruction that limits upstream migration of salmonids. A previous investigation of tributary spawning potential has identified Miocene Dam on the West Branch of the North Fork Feather River, Curtain Falls on the Middle Fork Feather River, and Ponderosa Diversion Dam on the South Fork Feather River as impassable fish barriers, and Big Bend Dam on the North Fork Feather River as an impediment to upstream passage at all but the highest reservoir levels (DWR 1993). These barriers to fish passage have been re-evaluated under Task 1A of SP-F3.1 to confirm the upstream geographic scope of this study plan. The downstream extent of the study area within the lower Feather River extends to the confluence of Honcut Creek. Within the Thermalito Complex, the study area includes the Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay.

1.1.2.1 Description

Lake Oroville and its tributaries, together with the Thermalito Complex, support multi-species “warmwater” and “coldwater” recreational fisheries. Fish species of management concern include black bass (*Micropterus* spp.), which contribute to the warmwater component of the fishery, and anadromous salmonid and trout species, which contribute to the coldwater component. Both fisheries provide a high recreational value to the general public. Trophy programs and tournaments have been established in the area for both the salmonid and black bass angling communities.

The Lake Oroville fishery is managed with the objectives of promoting a multi-species warmwater and coldwater fishery with the general goal of benefiting a diverse angling community. The Lake Oroville coldwater fishery is managed as a put-and-grow fishery with the primary objectives of producing trophy salmonids and providing a quality fishery characterized by high salmonid catch rates while the Thermalito Forebay coldwater fishery is managed as a put-and-take fishery (DWR 1999). Lake Oroville’s warmwater fishery is self-sustaining and includes four species of black bass (*M. punctulatus, M. salmoides, M. dolomieui,* and *M*. *coosae*), two species of sunfish (*Lepomis cyanellus* and *L. macrochirus*), two species of crappie (*Pomoxis nigromaculatus* and *P. annularis*), and two species of catfish, channel catfish (*Ictalurus punctatus*) and white catfish (*I. catus*).

In general, Lake Oroville thermally stratifies in the spring, destratifies in the fall, and remains destratified throughout the winter. Lake Oroville supports a two-story fishery, which means that it supports both coldwater and warmwater fish species that are thermally segregated for most of the year. The coldwater fish use the deeper, cooler, well-oxygenated hypolimnion, whereas the warmwater fish are found in the warmer, shallower, epilimnetic and littoral zones. When Lake Oroville destratifies, the two fishery components mix in their habitat utilization. The Lake Oroville coldwater fishery is managed as a put-and-grow fishery, meaning that hatchery raised fish are stocked in Lake Oroville as juveniles, with the intent that they will grow in the lake before being caught by anglers (DWR 2001). The coldwater fishery is sustained by hatchery stocking because natural recruitment to the Lake Oroville coldwater fishery is very low. The current salmonid fishery is not self-sustaining, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the upstream tributaries with sufficient spawning and rearing habitat (DWR 2001).

1.1.2.2 History

DFG has been involved with fishery management activities in the Feather River watershed for over 100 years. In the 1960s, DFG narrowed its focus from the watershed level and initiated fishery management activities within the FERC-project boundary. These activities included fisheries studies, species introductions, fish stocking programs, habitat enhancement projects, and operation of the Feather River Hatchery. While habitat restoration efforts and fish stocking from the Feather River Hatchery have increased fish production and provided increased angling opportunities in Lake Oroville, management actions such as the introduction of exotic species and disease propagation may have affected fishery resources in project waters. Downstream from the Oroville facilities, runs of natural anadromous salmonids and other resident species are affected by water releases from the dam, diversion pools associated with the project, and the effects of the project on water quality in the Feather River (DWR 2001). Potential impacts to natural fish populations upstream or downstream from Lake Oroville also may occur from fish stocked in Lake Oroville.

In 1994, FERC ordered DWR to formulate and implement a fisheries management plan that would “promote a multispecies warmwater and coldwater fishery with the general goal of benefiting a diverse angling community” in Lake Oroville (FERC 1994). DWR complied with the FERC orders by implementing salmon stocking and fish habitat improvement projects in Lake Oroville and submitting their fisheries management plan to FERC in February of 2000. The plan is currently under review by FERC. As a result of the 1994 FERC orders, DWR became involved with fisheries management activities within the FERC project boundary. Since that time, DWR has stocked over 1.9 million Chinook salmon in Lake Oroville and expanded the Feather River Hatchery to accommodate Lake Oroville stocking. In 1999 alone, the Feather River Hatchery raised approximately 500,000 yearling Chinook salmon, 25,000 of which were stocked in the Thermalito Forebay, 158,000 were placed in Lake Oroville, and the remainder were stocked in reservoirs outside of the Oroville area. From 1992 through 1997, several thousand Chinook salmon released into Lake Oroville were tagged with reward tags.

Some fish tagged with reward tags have been documented downstream of Lake Oroville in the Feather River below the Fish Barrier Dam, which suggests a potential for interactions between the Lake Oroville and Feather River fish populations. DWR has also implemented a warmwater fish habitat enhancement project, involving the planting and anchoring of over 28,000 trees (6,400 used Christmas trees, 200 manzanita trees, and 21,900 willow and button bush trees) at several locations in Lake Oroville to provide an additional microcover for protection of juvenile black bass.

Prior to the involvement of DWR in the management of the fisheries within the project area, DFG had conducted several fish stocking experiments. In the 1970s and 1980s the DFG stocked rainbow trout (*O. mykiss*) and lake trout (*Salvelinus namaycush*) in Lake Oroville with little success (DWR 2001). Rainbow trout are still caught in Lake Oroville in low numbers. DFG also experimented during the 1980s with stocking striped bass (*Morone saxatilis*) in the Thermalito Afterbay. Private fishing clubs also stocked Florida-strain largemouth bass (*M. salmoides floridanus*) in Lake Oroville; however, the species did not develop into a self-sustaining population and eventually disappeared.

Green sturgeon are infrequently observed in the lower Feather River from the Thermalito Afterbay Outlet to the confluence of the Sacramento River. Sturgeon are year-round residents of the Feather River and, therefore, all lifestages could be present. Anecdotal evidence indicates that green sturgeon are occasionally caught by anglers in the Feather River and that larval green sturgeon also have occasionally been caught in salmon outmigrant traps on the Lower Feather River (Moyle et al. 1995).

River lamprey are infrequently observed in the Feather River from the Fish Barrier Dam to the confluence with the Sacramento River and are reportedly less commonly observed in the Feather River than Pacific lamprey. Adults have been observed spawning in riffles near Honcut Creek, while juveniles rear in the river year-round (Cavallo et al. 2003; Moyle et al. 1995).

Hardhead are fairly common in the Sacramento River and lower mainstems of the American and Feather rivers. Hardhead are resident year-round and, therefore, all lifestages are present in the Feather River. Hardhead are frequently observed in the Feather River from the Fish Barrier Dam downstream to the confluence with the Sacramento River (Moyle 2002).

Rainbow trout and steelhead are genetically the same species, but are normally differentiated by differences in life history behavior. Steelhead exhibit an anadromous life history, while rainbow trout spend their entire lifecycle as freshwater residents (Moyle 2002).

Juvenile steelhead are frequently observed in the Feather River from the Fish Barrier Dam to the Thermalito Afterbay Outlet, and are infrequently observed from the

Thermalito Afterbay Outlet to Gridley Bridge. Juvenile steelhead may be present year-round in the Feather River (DWR 2003a).

Adult steelhead are frequently observed in the Feather River from the Thermalito Afterbay Outlet to the confluence with Honcut Creek during the spring and fall, and are frequently observed from the Fish Barrier Dam to the Thermalito Afterbay Outlet during the spring, summer, and fall. Adult steelhead immigration reportedly occurs from September though March, and spawning reportedly occurs from December through April (DWR 2003a).

Juvenile Chinook salmon are the most numerously observed fish in the Feather River (DWR 2002b; Moyle et al. 1995). Based on the reported adult immigration timing for spring-run and fall-run Chinook salmon and on the reported juvenile emigration periods for both spring-run Chinook salmon and fall-run Chinook salmon, the species could be found in the lower Feather River year-round (Cavallo 2003; DWR 2002b; Moyle et al. 1995). Juvenile Chinook salmon are reported to be frequently observed in the Feather River from December through June, from the Fish Barrier Dam to the confluence with the Sacramento River. Additionally, juvenile Chinook salmon are reportedly infrequently observed from July through November from the Fish Barrier Dam to the Thermalito Afterbay Outlet (DWR 2002b).

Sacramento splittail distribution is sporadic, and splittail use of the Feather River varies from year-to-year (Sommer et al. 1997). They are infrequently observed in the Feather River from the confluence with Honcut Creek to the confluence with the Sacramento River. Splittail are present in the Feather River during spawning, which generally extends from January through April, with peak spawning occurring in February and March.

The objectives for this study are to evaluate the effects of fisheries management activities on ESA-listed fish species and SSC in the Feather River. Management activities are divided into two categories; fish stocking activities and non-stocking activities.

Current fish stocking activities in the project area include the stocking of coho salmon in Lake Oroville and rainbow trout and brook trout (*Salvelinus. fontinalis*) in the Thermalito Forebay. Potential interactions among stocked fish and ESA-listed salmonids in the Feather River include competition for resources, predation, disease transmission, and genetic introgression. This report examines these interactions and evaluates the potential for negative impacts to populations of fish species of concern in the Feather River.

Non-stocking fisheries management activities in the project area include sport fishing regulations, habitat enhancements and genetic enhancements to warmwater fish species promoting growth and longevity. These activities are evaluated to determine potential detrimental effects on fish species of concern in the Feather River.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (MAF) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

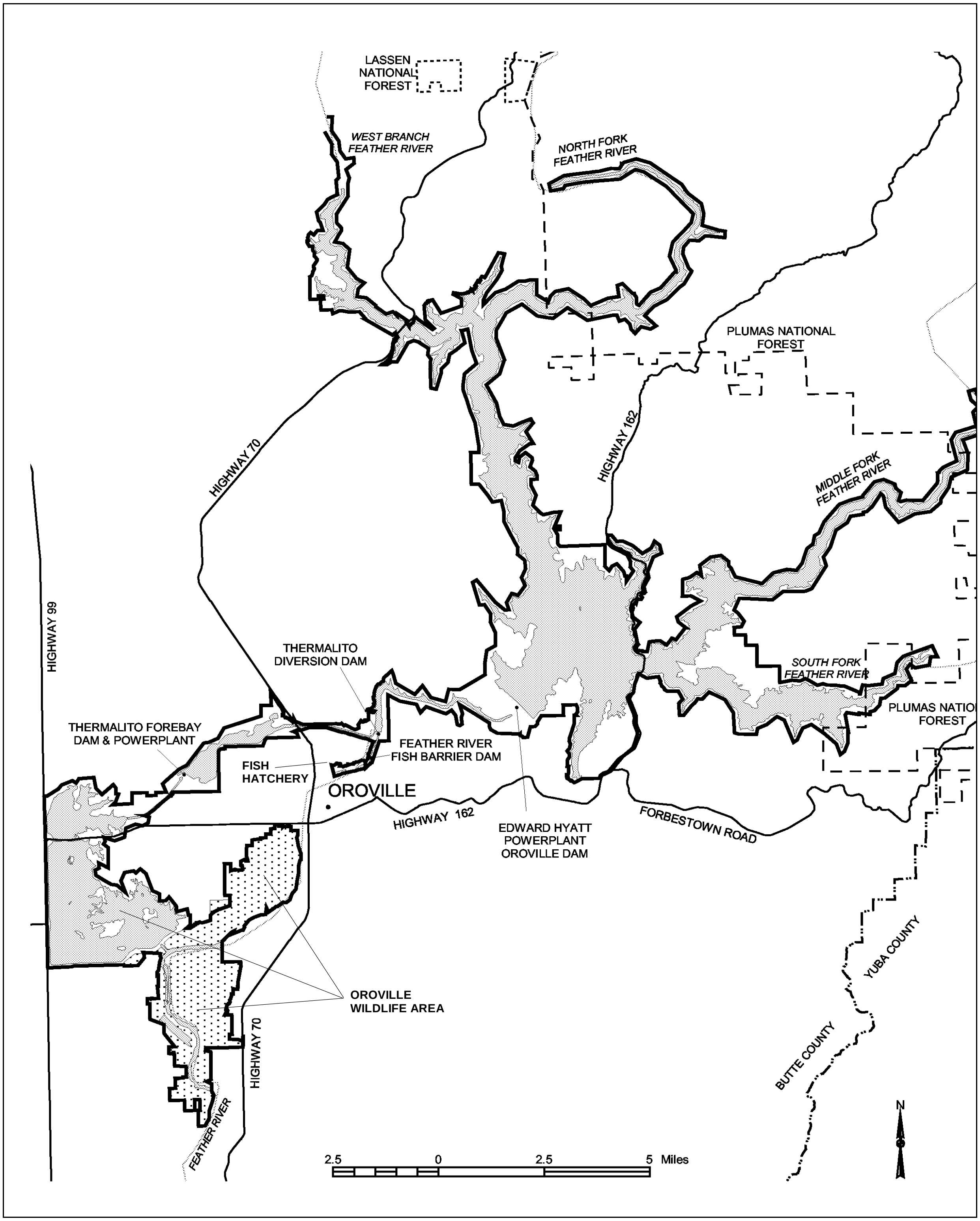

Figure 1.2-1. Oroville Facilities FERC Project Boundary.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively.

When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook salmon spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that

Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook salmon. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

NOAA Fisheries has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook salmon and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 MAF. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 MAF to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Task 1 is a subtask of SP-F5/7, *Evaluation of Fisheries Management on Project Fisheries*. Task 1 fulfills a portion of the FERC application requirements by identifying and characterizing the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species. In addition to fulfilling statutory requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

Performing this study is necessary, in part, because operations of the Oroville Facilities affect the fisheries management activities occurring within the study area and fisheries management activities occurring within the study area have the potential to influence ESA- and SSC-listed fish species by providing opportunities for interaction between fish species which otherwise may not have occurred. Performing this study is additionally necessary because the coldwater and warmwater fisheries are important facets of recreation at the Lake Oroville project. Components of the coldwater and warmwater reservoir fisheries management program have the potential to interact with ESA-listed species and Species of Special Concern in the Feather River. In order to evaluate the ability of the Oroville Facility to comply with the 1994 FERC orders, it is necessary to evaluate the effects of fisheries stocking and management practices on listed fish species.

Ongoing operation of the Oroville Facilities has the potential to influence ESA- and SSC-listed fish species by providing opportunities for interaction between fish species which otherwise may not have occurred. Task 1 of SP-F5/7, herein, identifies and characterizes the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species. Task 2 of SP-F5/7 evaluates the achievement of current stocking goals, while Task 3 of SP-F5/7 evaluates the interactions between the Lake Oroville fishery and upstream tributary fisheries. For further description of Tasks 2 and 3, see SP-F5/7 and associated interim and final reports.

3.0 STUDY OBJECTIVE(S)

The objective of SP-F5/7 Task 1 is to identify and characterize the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species.

3.1 APPLICATION OF STUDY INFORMATION

The purpose of SP-F5/7 Task 1 is to identify and characterize the potential effects of fisheries management activities occurring within the study area on ESA- and SSC-listed fish species. Data collected in this task also serve as a foundation for future evaluations and development of potential Resource Actions. Information obtained in this study is associated with, and will be applied to, the following purposes and activities.

3.1.1 Department of Water Resources/Stakeholders

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to evaluate potential effects of fisheries management on project fisheries. Additionally, data collected in this task serves as a foundation for future evaluations and development of potential Resource Actions.

3.1.2 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the FERC application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA) as well as the ESA. Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife, and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA and ESA, DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.3 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F5/7 Task 1 provides information, which may be useful in the development of potential Resource Actions to be negotiated during the collaborative process. Additionally, information obtained from this analysis of the effects of fisheries management activities on ESA- and SSC-listed fish species could be used during the collaborative settlement process.

4.0 METHODOLOGY

4.1 STUDY DESIGN

The objective of Task 1 of SP-F5/7 is to evaluate the potential effects of fisheries management activities on ESA-listed fish species and DFG designated SSC within the project area. Specifically, targeted species include fall-run Chinook salmon, spring-run Chinook salmon, steelhead, river lamprey, green sturgeon, hardhead and Sacramento splittail. To accomplish this objective, management activities were divided into two components. The first component evaluates potential effects of sport fish stocking activities, while the second evaluates potential effects of non-stocking management activities.

4.1.1 Study design for evaluating potential effects of sport fisheries stocking activities

In order to evaluate potential effects of sport fish stocking activities on ESA/SSC-listed fish species, historical stocking activities in Lake Oroville and the Thermalito Forebay were summarized using data obtained from DWR and DFG reports. Historical stocking data provide the groundwork for evaluating potential effects of stocking on fish species of concern in the Feather River. Following compilation of historical stocking records and reports, a literature review was conducted to determine potential interactions between stocked fish species and fish species of concern. Potential interactions considered in the literature review included competition, predation, disease transmission, and genetic introgression. Definitions for the types of interactions are provided in the section titled "How and Where the Studies Were Conducted". The literature review included a review of existing information sources including DWR and DFG stocking reports, studies by federal and state agencies, FERC Relicensing studies, scientific peer-reviewed papers, white papers and gray literature.

The information obtained from the literature review was used to evaluate the theoretical potential for interaction and the opportunity for interaction. The theoretical potential for interaction was evaluated based on information characterizing fish habitat and fish distribution as well as information describing ecological roles of fish species. For example, if northern pike (*Esox lucieus*) were one of the species stocked in the project area, northern pike theoretically could interact with a variety of fish species in the study area through predation, including salmonids. Thus, there is theoretical potential for interaction between northern pike and salmonids. In addition to evaluating the theoretical potential for interaction between fish species based on the material obtained from the literature review, the opportunity for interaction was also evaluated. Evaluation of the opportunity for interaction included consideration of the possibility of interaction based on physical proximity and the likelihood of project features to precipitate an interaction. In other words, if a stocked species could theoretically interact with a listed species, the opportunity for interaction was evaluated based on physical proximity of the two species or the potential for transit to specific locations for potential interactions. For example, consider a hypothetical scenario in which northern pike were stocked in the Thermalito Diversion Pool. Theoretically, northern pike could interact with a variety of fish species in the study area, including salmonids, as discussed above. Although northern pike could theoretically interact with salmonids such as coho salmon by preying upon them, the opportunity for interaction between the two species would be limited to areas where both species occur. In the study area, coho salmon are stocked in Lake Oroville. If northern pike were stocked in the Thermalito Diversion Pool, an interaction between coho salmon in Lake Oroville and northern pike stocked in the Thermalito Diversion Pool would be unlikely to occur because Oroville Dam limits the opportunity for northern pike and stocked coho salmon to be in sufficient physical proximity to allow regular predation interactions. This example illustrates that both the potential for interaction as well as the opportunity for interaction need to be considered in order to evaluate potential effects of stocking activities on ESA- and SSC-listed fish species.

Descriptions of how specific stocking related sport fish management activities were evaluated as well as definitions of the interactions evaluated (disease transmission, competition, predation, and genetic introgression) are presented in the section titled “How and Where the Studies Were Conducted". The "Results" section summarizes stocking-related sport fish management activities in the study area and describes the findings of the literature review regarding the potential for interactions between stocked species and ESA/SSC-listed species, including disease transmission, competition, predation, and genetic introgression. The "Analyses" section combines the information regarding the potential for interactions to occur as described in the "Results" section, with the opportunity for interaction to occur within the study area in order to evaluate the potential effects of sport fish stocking-related management activities.

4.1.2 Study design for evaluating potential effects of non-stocking management activities

In order to evaluate potential effects of non-stocking management activities on ESA/SSC-listed fish species, a review of DWR and DFG reports was conducted summarizing and describing non-stocking management activities in Lake Oroville, Lake Oroville’s upstream tributaries, the Thermalito Forebay, the Thermalito Diversion Pool, and the Thermalito Afterbay. Non-stocking management activities in the project area include fish habitat enhancement activities, and genetic enhancements to existing stocks of warmwater fish. After summarizing and describing the non-stocking management activities in Lake Oroville, Lake Oroville’s upstream tributaries, the Thermalito Forebay, the Thermalito Diversion Pool, and the Thermalito Afterbay, a second literature review was conducted to evaluate those activities that potentially affect fish species of concern in the Feather River. Literature reviews included a review of existing information sources including DWR and DFG reports describing management activities, studies by federal and state agencies, scientific peer-reviewed papers, white papers and gray literature.

The "Results" section describes the findings of the literature review summarizing the habitat and genetic enhancements conducted within the study area. The “Analysis” section presents a discussion of the opportunity for interaction. Additionally, the "Analyses" section combines the information describing habitat and genetic enhancements from the "Results" section with the opportunity for those actions to affect ESA/SSC-listed fish species in order to evaluate the potential effects of non-stocking management activities on ESA/SSC-listed fish species.

4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

Evaluations of potential effects of sport fish stocking activities and non-stocking management activities on ESA/SSC-listed fish species were conducted according to the study design described above. Descriptions of how specific stocking related and non-stocking related management activities were evaluated as well as definitions of the interactions evaluated (disease transmission, competition, predation, and genetic introgression) are presented below.

4.2.1. Evaluation of sport fish stocking activities

Fish currently stocked in the study area include coho salmon in Lake Oroville, and brook trout and rainbow trout in the Thermalito Forebay. The stocking of Chinook salmon and brown trout (*Salmo trutta*) in Lake Oroville was discontinued in 1999 because of disease concerns. Therefore, the portion of this study relating to fish stocking practices will focus on brook trout, rainbow trout and coho salmon.

Disease transmission, competition, predation, and genetic introgression were potential interactions evaluated between stocked fish and native fish species of concern in the Feather River. The potential for disease transmission among stocked fish and ESA-listed fish species in the Feather River will focus on those diseases investigated by SP-F2, *Evaluation of Project Effects on Fish Disease.* SP-F2 identified Infectious Hematopoietic Necrosis (IHN), ceratomyxosis, cold water disease, bacterial kidney disease (BKD) and whirling disease as significant diseases in the project area. Because each of these diseases has been shown to infect stocked species (brook trout, rainbow trout and coho salmon) and native salmonid species in the project area, disease transmission is discussed for all salmonid species rather than by individual species. These diseases are not known to infect non-salmonid species. The potential for competition, predation and genetic introgression with ESA/SSC-listed species will be discussed and evaluated for each of the stocked species independently. Definitions of the types of interactions evaluated (disease transmission, competition, predation, and genetic introgression) are presented in section 4.2.3.

4.2.2. Evaluation of non-stocking management activities

Non-stocking management activities in the project area primarily consist of habitat enhancements in Lake Oroville and genetic enhancements to fish comprising the warm water fishery. The potential effects of habitat enhancements and genetic enhancements on ESA/SSC-listed species are discussed separately, but because of similar potential effects, are not discussed individually for each ESA/SCC-listed fish species.

4.2.3 Definition of types of interactions

4.2.3.1 Definition of disease transmission

Disease transmission is defined as the passage of pathogens from an infected host to other individuals of the same or different species. Technically, transmission can occur without causing harm to the new host – transmission is only the transfer of the pathogen and has little to do with manifestation of the disease (i.e., a fish resistant to IHN can still carry the virus and transmit it to other individuals, even though the resistant individual doesn't contract the disease itself). Disease transmission is one type of interaction that could occur between stocked fish and fish in the Feather River without a spatial or temporal overlap among the different species. An outbreak of disease in the Feather River Hatchery could theoretically spread pathogenic microorganisms downstream from the hatchery through the water supply.

Project effects on fish diseases were evaluated under SP-F2. Diseases occurring in the Feather River Basin that are considered significant, in that they are major contributors to fish mortality, include IHN, ceratomyxosis, cold water disease, BKD, and whirling disease. Although these diseases occur naturally, it has been suggested that hatchery production could amplify any outbreaks and increase the likelihood of transferring the diseases to ESA-listed salmonids downstream on the Feather River. None of these diseases are known to infect non-salmonid species.

4.2.3.2 Definition of competition

The most widely used definition of competition in the scientific literature is that competition "occurs when a number of animals (of the same or different species) utilize common resources the supply of which is short; or if the resources are not in short supply, competition occurs when the organisms seeking that resource nevertheless harm each other in the process."(Birch 1957).

Prior to the late 1970s it was generally thought that competition played a key role in determining species coexistence. Since that time an alternative view has gained acceptance. The current view suggests that varying ecological conditions coupled with species life history plays a greater role than direct competition for resources in determining species abundance (Allan 1995). As an example, two species may coexist in a particular stable environment. Both species utilize similar spawning habitat, but there is sufficient spawning habitat such that it is not a limiting factor. If a significant amount of spawning habitat were removed from the system, competition for that remaining habitat may occur and one species may dominate.

The occurrence of competition is difficult to prove because there are two possible outcomes to competition between species occupying the same ecological niche: either the weaker competitor will become extinct, or one of the species will evolve enough to use a different set of resources (Campbell 1987). It is difficult to demonstrate the existence of competition because, by its very nature, generally competition does not occur for long periods of time (Campbell 1987). Studies seeking to illustrate the existence of competition must demonstrate an adverse effect on the numbers of individuals of one species due to the abundance of individuals of another species under natural conditions, and they must provide a reasonable explanation of the mechanism (Allan 1995). Studies seeking to demonstrate competition generally include manipulation of the population through removal experiments (Allan 1995).

4.2.3.3 Definition of predation

In addition to competition, species may directly interact through predation. Predation occurs when individuals of one species eat individuals of the same or another species. White and Harvey (2001) suggest that the potential for predation may also have an indirect effect in that a response to the presence of larger piscivorous fish in pools may cause smaller fish to move to shallower riffles, where increased predation by birds or mammals could occur.

All three species of stocked salmonids in the project area are piscivores and have the potential to prey on ESA/SSC-listed species of concern in the Feather River. Rainbow trout are the same species as steelhead but generally refer to the non-anadromous life history form. Neither brook trout nor coho salmon are native to the lower Feather River and stocking of these species should be considered exotic species introductions. Fisheries scientists maintain differing views on the impact of introduced species. Some researchers maintain that introduced species are one of the most important factors causing the extinction or threatened status of native fishes in North America (Lassuy 1995). Moyle and Light (1996) suggest that exotic species introductions only present a serious threat in cases where the introduced species are piscivores or have the ability to hybridize with native species.

4.2.3.4 Definition of genetic introgression

There are two types of genetic introgression of concern to fisheries scientists. The first is inter-specific introgression that occurs when two different species hybridize. This typically results in sterile progeny. In some cases (i.e.: rainbow trout x cutthroat trout

(*O. clarki*)) progeny is fertile and the first generation may display hybrid vigor (Leary et al. 1995). Of those species within the project area, there is some evidence that hybridization between coho salmon and Chinook salmon could occur.

Conspecific introgression occurs when different populations of the same species reproduce. Within the project area this would be possible if stocked rainbow trout were to reproduce with native steelhead populations in the Feather River. It also could potentially occur if spring-run Chinook salmon and fall-run Chinook salmon reproduce with each other. Study plan reports produced for SP-F9 will provide additional information regarding potential genetic introgression between spring-run Chinook salmon and fall-run Chinook salmon.

There is a strong perception that hatchery fish may negatively affect the genetic constitution of wild fish (Hindar et al. 1991; Waples 1991). One of the main factors contributing to this perception is the observation of a reduction in wild fish populations following the initiation of a hatchery release program (Hilborn 1992; Washington and Koziol 1993). An explanation offered for this observation is that hatchery fish are adapted to the hatchery environment; hence, natural spawning with wild fish reduces the fitness of the natural population (Taylor 1991). Campton (1995), reviewed the literature on genetic effects of hatchery fish and wild stocks of Pacific salmon and steelhead, and concluded that most genetic effects detected to date appear to be caused by hatchery or fishery management practices and not biological factors intrinsic to hatcheries or hatchery fish.

There is some evidence for conspecific introgression in U.S. coastal populations of steelhead. Substantially less genetic divergence has been observed between populations along the coast of California, Oregon and Washington than is observed in British Columbia populations. It has been suggested that the introduction of hatchery steelhead, mainly from a single source, has been common in the former area but rare in British Columbia (Reisenbichler et al. 1992). Leary et al. (1995) suggest that this is because hatchery straying has increased gene flow among the populations. They suggest the same explanation for the smaller amount of genetic divergence observed in the heavily stocked Sacramento and San Joaquin rivers population of Chinook salmon compared to other less heavily stocked rivers in California (Bartley et al. 1992).

5.0 STUDY RESULTS

5.1 STOCKING-RELATED SPORT FISHERIES MANAGEMENT ACTIVITIES

5.1.1 Summary of stocking-related sport fisheries management activities

5.1.1.1 Stocking activities in Lake Oroville

A variety of salmonids have been stocked in Lake Oroville beginning in 1968. From 1968 to 1978, rainbow trout, brown trout, coho salmon, and kokanee salmon (*O. nerka*) were the principally stocked salmonids (DWR 1999). Beginning in 1979, coho salmon and kokanee salmon were no longer stocked and Chinook salmon were stocked as a substitute (DWR 1999). Beginning in 1988, rainbow trout were no longer stocked (DWR 1999). From 1988 to 2000, brown trout and Chinook salmon were the principally stocked salmonids in Lake Oroville (DWR 1999). From 1990-2000, the Lake Oroville coldwater fishery was managed for Chinook salmon and brown trout (DWR 1999). Recent disease concerns, including the prevalence of infectious hematopoietic necrosis virus (IHNV), have prompted changes in the stocking procedures at Lake Oroville. Due to their susceptibility to IHN, Chinook salmon and brown trout are not currently being stocked. Coho salmon were stocked as a replacement for Chinook salmon and brown trout in order to maintain an attractive coldwater fishery in Lake Oroville, as they are less susceptible to IHN (DWR 2002d).

Historical data illustrating stocking activities in Lake Oroville from 1993 through the present are presented in Table 5.1-1. From 1993 through 2000, Chinook salmon and brown trout were the only salmonid species stocked in the lake.

Table 5.1-1. Salmonid stocking activities in Lake Oroville (1993 – 2002).

Year	BN-FING	BN-SUB	BN-CAT	ChS-FING	ChS-YEAR	CoS-FING	CoS-YEAR
1993	0	123655	7800	102585	60650	0	0
1994	0	50004	0	104410	55200	0	0
1995	0	65400	0	101922	90001	0	0
1996	8402	80200	0	105841	150435	0	0
1996	0	67403	0	105000	250000	0	0
1998	0	55000	0	106163	352970	0	0
1999	0	50008	0	128750	158290	0	0
2000	0	155700	0	0	28600	0	0
2001	0	0	0	0	0	0	0
2002	0	0	0	0	0	50249	128280

Legend
BN = Brown Trout   FING = Fingerling
ChS = Chinook Salmon   SUB = Sub-catchable
CoS = Coho Salmon   CAT = Catchable
YEAR = Yearling

Source (DWR 2003b)

Current annual salmonid stocking recommendations for Lake Oroville were formulated in 2000 and are based on a 5-year study conducted jointly by DFG and DWR in Lake Oroville (DWR 1999). The joint five-year study was conducted in order to gather data for determining the optimum stocking rate for salmonids in Lake Oroville (FERC 1994). Although there was a history of salmonid stocking in Lake Oroville prior to the initiation of this five-year study, there had never been systematic measurements to establish the effects of stocking salmonids on other reservoir fish species and to establish the optimum level of stocking (FERC 1994). The five-year joint study proposed an experimental stocking approach designed to produce a sound fish stocking policy. DFG and DWR stocked successively increasing numbers of salmonids in Lake Oroville each year, while utilizing mark-recapture techniques to collect information such as angler harvest, survival, and growth (DWR 1999). Additionally, the study collected creel survey data and hydroacoustic data to assess the effects of increasing salmonid stocking on the black bass population and the forage base, respectively (DWR 1999). The study was conducted from July 1993 through June 1999, with increasing numbers of yearling equivalent Chinook salmon stocked each year (DWR 1999). A "yearling equivalent" was defined as the number of fingerlings and yearlings stocked in combination that would produce a similar angler catch if only yearlings are stocked and is based on return rates of coded wire tagged Chinook salmon in the recreational fishery (DWR 1999). The annual stocking recommendations for Lake Oroville resulting from the five-year study were 170,000 Chinook salmon yearling equivalents (DWR 1999). This recommendation was chosen in order to provide for a quality salmonid fishery and provide for trophy fishing opportunities (DWR 1999). The objective of the stocking program is to produce salmonids greater than or equal to five pounds (DWR 1999). In order to meet this objective, DFG suggested length-at-age targets for Chinook salmon at 12, 18 and 24 months of age (DWR 1999). The annual stocking recommendation of 170,000 yearling equivalent Chinook salmon was the highest stocking density, which resulted in attainment of length-at-age targets. These recommendations were submitted to FERC on February 15, 2000 (DWR 1999).

During the spring of 2000, the Feather River Hatchery experienced an outbreak of IHN. As a result of this outbreak, all inland Chinook salmon on station at the hatchery were destroyed to prevent the spread of the pathogen to the lower Feather River. In July 2000 DWR notified FERC that stocking recommendations developed in the 2000 report would be suspended pending analyses by DFG fish pathologists (DWR 2003b). Based on these analyses, new recommendations were developed by DWR that replaced inland Chinook salmon stocking with coho salmon stocking. In 2002, DWR purchased 300,000 coho salmon eggs from a private aquaculture facility in Washington. These eggs were hatched and fish were reared at the Feather River Hatchery, and then stocked in Lake Oroville in 2002. A total of 178,529 fish were stocked (50,249 fingerlings and 128,280 yearlings). Currently, the salmonid stocking strategy for Lake Oroville is to stock 170,000 +/- 10% yearling coho salmon equivalents. This strategy will remain in effect until January 2007 (DWR 2003b).

Regarding coho stocking procedures, fingerlings are stocked in the spring while yearlings are stocked in the fall. The decision as to the numbers of fingerlings or yearlings stocked each year is primarily based on hydrological conditions. For example, in wet years fewer fingerlings are stocked to reduce the probability of losing fish over the spillway (DWR 2003b). This decision must be weighed against the cost and risk of disease associated with maintaining the fish in the hatchery environment for a longer period of time.

5.1.1.2 Stocking activities in the Thermalito Forebay

Stocking activities in the Thermalito Forebay from 1993 through 2001 are presented in Table 5.1.1.2-1. The Thermalito Forebay is managed by DFG as a put-and-take trout fishery, where rainbow trout and brook trout of approximately ½ pound (227 g) are stocked biweekly (DWR 2002d). Criteria used by DFG for the stocking of California reservoirs are to begin stocking when water temperatures reach 42^{o}F and end when water temperatures reach 78^{o}F (DFG 2004). Average annual stocking in the Thermalito Forebay (1993 - 2001, omitting 1996) is 33,600 rainbow trout (range: 18,380 – 77, 400 with no fish stocked in 1996). During this same time period an average of 9,800 brook trout were stocked annually (range: 8,600 – 14,640 with no fish stocked in 1995 or 1996). In addition to regularly scheduled rainbow and brook trout stocking, supplemental stocking has occurred on a limited basis. For example, in 1993, 1994, and 2000, supplemental stocking of brown trout, rainbow trout, and Chinook salmon, respectively, occurred in the Thermalito Forebay (Table 5.1-2). Salmonid stocking objectives for the Thermalito Forebay are not as well defined or documented as those for Lake Oroville.

Table 5.1-2. Salmonid stocking activities in Thermalito Forebay (1993 – 2001).

Year	Rainbow Trout	Brook Trout	Brown Trout	Chinook Salmon	Eagle Lake Rainbow Trout
1993	32190	14640	7400	0	0
1994	77400	5760	0	0	0
1995	40240	0	0	0	0
1996	0	0	0	0	0
1997	29300	10660	0	0	0
1998	18380	10150	0	0	0
1999	24450	9740	0	0	4000
2000	24700	8840	0	25000	0
2001	22400	8600	0	0	0

Source (Eric See, DWR, pers comm.)

5.1.1.3 Stocking activities in the Thermalito Diversion Pool and Thermalito Afterbay

No direct stocking activities occur in either the Thermalito Diversion Pool or in the Thermalito Afterbay. However, because no barriers exist between the Thermalito Forebay and the Thermalito Diversion Pool, fish stocked in the Thermalito Forebay could potentially freely move between the two areas. Thus, the Thermalito Diversion Pool remains an important coldwater sport fishery with trophy salmonids caught there each year (DWR 2002d). The Thermalito Afterbay also provides habitat capable of supporting both a coldwater and warmwater fishery as discussed in SP-F3.1 Task 4B, *Characterize Cold Water Pool Availability in the Thermalito Afterbay*. Trout are caught each year in the Thermalito Afterbay even though no direct salmonid stocking occurs. Trout caught in the Thermalito Afterbay probably passed from the Thermalito Forebay through the Thermalito Pumping-generating Plant and into the Thermalito Afterbay.

5.1.2 Summary of literature review describing disease transmission, competition, predation and genetic introgression

5.1.2.1 Disease Transmission

Project effects on fish diseases were evaluated under SP-F2. This portion of this task focuses on the potential effects of stocking-related management activities on disease transmission. Diseases identified as significant within the project area include IHN, ceratomyxosis, cold water disease, BKD, and whirling disease. Pathogens that cause these diseases are endemic to the project area and are common problems in fish culture facilities raising salmonids.

IHN

IHN is a major cause of mortality in Chinook salmon, sockeye salmon and steelhead in fresh water (Noga 1996). As high as 100 percent mortality can occur in these species when less than six months old, while older fish have lower mortality and may not display clinical signs of the disease. Clinical signs include lethargy, abdominal distension and a darkening of abdominal tissue (Noga 1996). Coho salmon, brown trout, brook trout and cutthroat trout are generally considered immune to the disease (Noga 1996). Noga (1996) reports that water temperature plays an important role in IHN epidemics with peak mortality occurring at 10^{o} C (50^{o} F), and lower mortality below 10^{o} C (50^{o}F). Noga (1996) did not report specific percentages of mortalities, however, he did cite Amend (1970) as stating that no documented mortalities above 15^{o} C (59^{o} F) have been reported.

During epidemics, IHN is readily transmitted horizontally, or from one individual to another. Ectoparasites (e.g., leeches) and insects are considered reservoirs for the virus (Noga 1996). Disinfection and quarantine are currently the only proven methods of controlling IHN epidemics (Noga 1996).

Ceratomyxosis

Ceratomyxosis is caused by *Ceratomyxa shasta*, an endemic myxosporean parasite that is lethal to many strains of rainbow trout. The parasite is prevalent in both the waters of the Thermalito complex and Lake Oroville (DWR 2001). Ceratomyxosis can cause up to 100 percent mortality among juveniles and is also a cause of pre-spawning mortality in salmon (Noga 1996). Rainbow trout, Chinook salmon, and chum salmon (*O. keta*) are the species most susceptible to ceratomyxosis, while coho salmon, brown trout and brook trout are less susceptible (Noga 1996). Horizontal transmission of the disease from one individual to another has not been documented and the necessity of an intermediate host is strongly suspected (Noga 1996).

Salmonid populations that are native to rivers where *C. shasta* naturally occurs appear to have developed varying degrees of resistance to infection (Noga 1996). Rainbow trout stocked in the Thermalito Forebay are particularly sensitive to *C. shasta* infections. It is suspected that most stocked rainbow trout not caught in the fishery die of this infection within three months of exposure to the parasite (DWR 2003c).

Cold water disease

Coldwater disease is caused by the bacterium *Flavobacterium psychrophilium*. This bacterium is known to infect hatchery and wild populations of virtually all salmonids, although coho salmon may be particularly susceptible (Noga 1996). The disease can cause up to 50 percent mortality among juvenile salmonids (Noga 1996). The bacterium can be found on clinically normal fish, suggesting skin damage may be necessary to initiate infection (Holt 1993 *in* Noga 1996). The natural reservoir of the bacteria has not been identified but vertical transmission is considered likely (Noga 1996). Early cases of coldwater disease have been successfully treated with oxytetracycline baths. Wood (1974) and Leon and Bonney (1979) *in* Noga (1996) suggest that keeping alevins in shallow rather than deep troughs, keeping water flows in incubators low, and inhibiting excessive movement of alevins to prevent abrasions can reduce infections.

BKD

Bacterial kidney disease (BKD) is a chronic disease, economically significant to hatcheries, particularly those raising Pacific salmon, because of its widespread distribution in both freshwater and saltwater environments. The disease is caused by *Renibacterium salmoninarium* and only occurs in salmonids. Although any age fish is susceptible to the disease, losses do not typically occur until the fish are over six months old (Noga 1996). Even fish with severe infections may have no external signs (Noga 1996). The disease is transmitted both horizontally and vertically. Vertical transmission is particularly problematic because the bacterium resides within the yolk and is protected from antiseptics (Evelyn et al. 1985) as reported in (Noga 1996).

There are no proven methods to eradicate BKD infection in fish (Noga 1996). Injection of female broodstock with erythromycin can, however, prevent vertical transmission of the disease (Moffitt 1992). Female broodstock should be injected at least nine days before spawning (Armstrong et al. 1989) as reported in (Noga 1996).

Whirling disease

Whirling disease has caused severe damage to rainbow trout populations in Montana and Colorado. Although the parasite causing the disease (*Myxobolus cerebralis*) has been found in California waterways, including the Feather River, no adverse effects on either native or stocked salmonid populations have been observed, as reported in SP-F2. Severity of the disease is inversely proportional to the age of the fish at first exposure. Newly hatched fry can suffer 100 percent mortality, while fish over six months old show virtually no clinical signs (Noga 1996).

Currently, hatcheries can only eliminate whirling disease by disinfection, quarantine, and re-population with pathogen free stock. Raising fish in concrete raceways is also a helpful prevention measure, as the intermediate host for the organism is the sludge worm (*Tubifex tubifex*) (Noga 1996).

5.1.2.2 Competition, Predation and Genetic Introgression

Rainbow trout

Rainbow trout and steelhead are the same species. Steelhead are differentiated from rainbow trout in having an anadromous life history. Regardless of their life history strategy, for the first year or two of life, both steelhead and rainbow exhibit similar juvenile life history characteristics (Moyle 2002).

Most wild rainbow trout spawn in the spring between February and June (Moyle 2002). Rainbow trout normally spawn by constructing redds (nests) in coarse gravel substrate, 0.5 to 5.1 inches in diameter, in the tail of a pool or riffle (Moyle 2002); preferred gravel size is reported to be 0.25 to 3.0 inches in diameter (USFWS 1995c). The number of eggs per female normally depends on size of the fish at spawning but ranges from 200 to 12,000 eggs (Moyle 2002). Most spawning is observed when water temperatures are between 46 and 52^{o}F in water flowing at from 0.2 to 3.6 ft/sec (USFWS 1995c). Water temperatures above 63^{o}F are reportedly lethal to developing rainbow trout embryos (Moyle 2002). Eggs normally hatch in three to four weeks with alevins remaining in the gravel for another two to three weeks (Moyle 2002).

For the first year of life, juvenile rainbow trout normally inhabit cool, fast-flowing streams and rivers where riffles predominate over pools and there is cover from riparian vegetation and undercut banks (Moyle 2002). Older rainbow trout tend to move into deeper runs or pools (Moyle 2002). Rainbow trout are reportedly found where daytime water temperatures range from 32^{o}F in the winter to 80.6^{o}F in the summer although 73.4^{o}F is reportedly lethal for unacclimated fish (Moyle 2002).

Rainbow trout feed mainly on insects with fish becoming an important part of their diet when lengths exceed 11 inches (Moyle 2002). Rainbow trout normally become sexually mature in their second or third year and normally live to age five although 11 year old rainbow trout have been reported (Moyle 2002).

Rainbow trout interactions with steelhead

Adult spawning steelhead utilize similar spawning habitat as rainbow trout and for the first year or two of life utilize similar habitat as juvenile non-anadromous rainbow trout (Moyle 2002). Because both the anadromous and non-anadromous forms of the species overlap in their habitat utilization and diet, they would be expected to compete for food and space if both forms were present simultaneously (McMichael et al. 1997). It has also been observed that juvenile steelhead can become prey for older rainbow trout (USFWS 1995c).

Stocked rainbow trout also present the only potential for conspecific genetic introgression among stocked fish and native salmonids in the Feather River. Because stocked rainbow trout are the same species as native Feather River Steelhead, the potential for genetic introgression exists if the two stocks are present during spawning. There is some evidence for conspecific introgression in U.S. coastal populations of native steelhead and hatchery reared steelhead or rainbow trout (Leary et al. 1995). Levels of genetic introgression among populations of the same species are often measured by genetic divergence (Reisenbichler et al. 1992). Leary et al. (1995) suggests that higher levels of stocking rainbow and steelhead in U.S. coastal waters is responsible for smaller levels of genetic divergence measured in U.S. populations compared to Canadian populations of steelhead.

Unfortunately, little is known about the abundance of steelhead spawners in the Feather River. Other than initial counts made prior to project construction, no data are available regarding escapement of naturally spawning steelhead in the Feather River (DWR 2001). Unlike the estimates available for in-channel Chinook salmon spawners, little specific information is available regarding the magnitude of steelhead spawning in the Feather River (DWR 2002a). Despite this lack of quantitative numerical estimates of the number of adult steelhead spawners, available information regarding young-of-year (YOY) steelhead distribution and adult steelhead spawner surveys. Information regarding the distribution of spawning steelhead in the Feather River can be inferred from observations collected during the snorkel surveys performed by DWR from March through August in 1999, 2000 and 2001. From 1999 to 2001, almost all of the steelhead spawning activity appears to have been concentrated between the Fish Barrier Dam and the Thermalito Afterbay Outlet, because 91 percent, 77 percent, and 84 percent of all the YOY steelhead observations during the snorkel surveys of 1999, 2000 and 2001, occurred a mile downstream of the Fish Barrier Dam, and only one percent of the YOY were observed downstream of the Thermalito Afterbay Outlet (DWR

2002a). Results from steelhead redd surveys conducted by DWR and reported in SP-F10 Task 2B also indicated that the majority of spawning activity occurs at the upstream end of the LFC, particularly in the vicinity of the FRFH.

Rainbow trout interactions with Chinook salmon

Feather River Chinook salmon spawn in the fall between September and December, with spring-run Chinook salmon generally peaking in mid-September while fall-run peak in mid to late November (Yoshiyama et al. 1998). Although Chinook salmon spawn in similar habitat to rainbow trout, there is a temporal separation in that rainbow trout spawn in the spring. Chinook salmon egg incubation is reported to require six to nine weeks in the Sacramento and San Joaquin River drainages (USFWS 1995c). After hatching, larvae reportedly remain in the gravel for four to six weeks until the yolk sac is absorbed (Moyle 2002). Juvenile emergence in the Sacramento River Basin generally occurs from November through March for spring-run and from December through March for fall-run Chinook salmon (Yoshiyama et al. 1998).

In the Sacramento River Basin, juvenile Chinook salmon stream residency, from emergence to emigration, ranges from three to 15 months for spring-run and one to seven months for fall-run (Yoshiyama et al. 1998). Prior to emigration, juveniles inhabit low water velocity areas with ample cover provided by undercut banks and submerged emergent vegetation to provide refuge from predators (DWR 1999). The optimal water temperature for survival and growth of juvenile Chinook salmon is reported to be from 53° to 64°F (USFWS 1995c). Emigration of juvenile Chinook salmon in the Feather River occurs from December through June (Sommer et al. 2001) with peak emigration occurring between January and April (Seesholtz et al. 2003). Nearly all fall-run size juvenile Chinook salmon (>95%) emigrate from the reach of the Feather River extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet within a few weeks of emergence (DWR 2003a). The main food source for rearing juveniles consists of chironomid midges and other aquatic insects (Moyle 2002). Rearing locations for Feather River Chinook salmon are largely unknown, but in wetter years juveniles are known to rear from weeks to months in the Yolo bypass immediately downstream from the Feather River confluence with the Sacramento River (Sommer et al. 2001). Seesholtz et al. (2003) speculate that this early emigration may be caused by competition with other juvenile salmonids, including Chinook salmon and steelhead, for rearing habitat.

McMichael et al. (1997) investigated effects of hatchery reared steelhead and rainbow trout on Chinook salmon in enclosure experiments and found that hatchery steelhead or rainbow trout have little effect on Chinook salmon populations, and suggest that the two species occupy different ecological niches and competition for resources is not likely. Rainbow trout over 11 inches in length are piscivores with diets consisting mainly of sculpins and suckers, although they are opportunistic feeders and also will feed on juvenile salmonids including steelhead and Chinook salmon (Moyle 2002). Hybridization between rainbow trout and Chinook salmon has not been documented in the wild.

Rainbow trout interactions with green sturgeon

Green sturgeon are anadromous fish that spawn in rivers, but spend most of their life in estuarine and marine environments. Green sturgeon are known to migrate into the Feather River, but detailed information regarding their reproduction is limited (USFWS 1995a). During the mid-1970s, green sturgeon were reportedly captured each year in the Feather River, with the majority of catches occurring between March and May (USFWS 1995a). As recently as 1993, adult green sturgeon have been caught near the Thermalito Afterbay Outlet (USFWS 1995a).

Adult green sturgeon appear to begin migration upstream into freshwater during the latter part of February and, in the Sacramento River, may continue migrating up to 200 miles before spawning (Beamesderfer and Webb 2002). Catch data indicate that most green sturgeon spawning in the Feather River occurs between March and May (USFWS 1995a).

Green sturgeon do not build nests; instead, adults broadcast spawn into the water column (Pacific States Marine Fisheries Commission 1996). Spawning occurs in deep, turbulent mainstem areas of rivers over large cobble (Beamesderfer and Webb 2002). Spawning may occur in water temperatures ranging from 46.4^{o}F to 57.2^{o}F (DFG 2002a; Moyle 2002). The time from fertilization to hatching is typically 4 to 12 days (DFG 2001a). Larvae typically emerge from the substrate six days after hatching (Deng et al. 2002).

Very little is known of juvenile rearing habitat preferences (Deng et al. 2002), although juveniles have been captured in estuaries and on the continental shelf (Environmental Protection Information Center et al. 2001), suggesting minimal rearing time in freshwater.

Interactions between rainbow trout and green sturgeon would be minimal. The species use different spawning habitat and juveniles seem to spend little time in freshwater. Predation on both juvenile and adult green sturgeon, other than man and large marine mammals, is rare (SWRI 2002). Because rainbow trout are opportunistic feeders, some minimal amount of predation may occur, but no literature on this topic was found.

Rainbow trout interactions with river lamprey

River lamprey are an anadromous coldwater fish. Based on studies in British Columbia, adult upstream migration occurs in the autumn. The range and more precise timing of adult migration is unknown (Moyle 2002). River lamprey spawning occurs during April and May (Wang 1986). River lamprey construct redds in riffles of small tributaries with gravel substrate (Beamish and Neville 1995; Moyle 2002). Larval lamprey spend several years buried in the soft bottom parts of rivers and streams feeding on small particles filtered from the water (Malmqvist 1986). During this time they are referred to as ammocoetes with transformation to adults occurring when ammocoetes reach 4.7 inches in length (Moyle 2002). Transformation to the adult stage may require nine months (Beamish 1980). River lamprey migrate to the Ocean from May through July (Beamish 1980).

Although river lamprey spawn in similar habitat to rainbow trout, they spawn at a different time of the year. Juvenile rearing is in a different habitat so competition during any life stage should not be a factor. At present, there is little evidence of predation by other animals on river lamprey. In laboratory experiments, in freshwater, salmon fed on small adult western brook lamprey so predation of river lamprey by rainbow trout may occur (Beamish 1980).

<u>Rainbow trout interactions with hardhead</u>

Hardhead are considered a warmwater fish preferring water temperatures above 68^{o}F (Moyle 2002). Hardhead normally spawn in riffles with a gravel substrate (Moyle 2002). Juvenile recruitment suggests that hardhead spawn from May through June in Central Valley streams, but the spawning may extend into August in the foothill streams of the Sacramento- San Joaquin drainage (DFG 2000).

Juveniles tend to concentrate in shallow water close to stream bank edges (DFG 2000). Water temperatures where juveniles were observed in the Pit River of California ranged from 61.8 to 68.4^{o}F (Baltz et al. 1987). Other than avian predation and predation by non-native fish species, predation on juveniles has not been reported (Moyle 2002).

Rainbow trout spawn at a different time of the year and juveniles rear in different habitat types than hardhead; therefore, competition during different life stages should not play a factor. Opportunistic predation by rainbow trout on juvenile hardhead may occur (Moyle 2002).

<u>Rainbow trout interactions with Sacramento splittail</u>

Sacramento splittail enter the lower reaches of the Feather River on occasion and have been reported upstream as far as Oroville (USFWS 1995b). Splittail are considered a warmwater fish (Wang 1986). Adult Sacramento splittail display a gradual upstream migration during the winter and spring months to spawn in flooded areas during March and April (Moyle 2002). Spawning is generally on submerged vegetation (USFWS 1995b).

Egg incubation normally requires three to seven days (Moyle 2002) with juveniles residing in shallow weedy areas near the emergence site for 10 to 14 days and move into deeper water as they mature (USFWS 1995b). Laboratory studies indicate that preferred water temperatures for juvenile splittail range from 71.6 to 75.2^{o}F (Young and Cech Jr. 1996). Downstream movement of juvenile splittail probably occurs between May and June. (Meng and Moyle 1995) Young-of-the-year Sacramento splittail are reportedly caught in the South Delta pumping plants from April through August, presumably while moving downstream to the estuary (Moyle 2002).

Rainbow trout spawn at a different time of the year and juveniles rear in different habitat types than splittail; therefore, competition during different life stages should not play a factor. Known predators of splittail include striped bass and pikeminnow (Moyle 2002; Wang 1986).

Brook trout

Brook trout are currently stocked in the Thermalito Forebay and there is a documented catch of a brook trout by a rotary screw trap in the lower Feather River (Seesholtz et al. 2003). Although brook trout are not native to western states, they are extensively stocked in western waters (Moyle 2002). Brook trout are a non-anadromous cold-water species.

Brook trout are fall spawners but particular timing is dependent on water temperatures generally between 39 and 52^{o}F (Moyle 2002). Brook trout prefer riffles with a pebble or gravel substrate near an area of upwelling for spawning (Moyle 2002). Juveniles rear in fairly shallow water near stream banks with emergent vegetation feeding primarily on insects (Moyle 2002). Although brook trout have been reported to hybridize with brown trout in the wild (Moyle 2002), hybridization with species of concern in the Feather River is not known to occur.

Brook trout interactions with steelhead

While there is virtually no literature specifically addressing brook trout interactions with steelhead, interactions between brook trout and rainbow trout have been extensively studied. For the first year or two of life, both steelhead and rainbow exhibit similar juvenile life history characteristics, therefore these studies would be applicable to any potential interactions among juveniles of both species (Moyle 2002).

Experiments were conducted on several streams in the Great Smokey Mountain National Park on native brook trout interactions with introduced rainbow trout (Moore et al. 1983). These experiments involved the removal of rainbow trout over a six-year period. At the beginning of the experiment, the downstream sections of the streams contained only rainbow trout. The middle portion of the streams contained both species and the upstream sections contained only brook trout. The experiment showed that, after removal of rainbow trout, brook trout were found throughout the length of the stream. This presents strong evidence of competitive exclusion of subordinate brook trout by the dominant rainbow trout.

Paradoxically, the two species prefer different microhabitats and little opportunity for competitive interactions should exist. Brook trout prefer low velocity positions in pools adjacent to cover (Butler and Hawthorne 1968) while rainbow trout prefer higher velocity riffles and runs (Moyle 2002). There has been speculation that competition might only be a factor in young-of-the-year fish of these species when sympatric (Larson and Moore 1985).

Larger brook trout are piscivores so some predation on juvenile steelhead may occur. Hybridization between rainbow trout and brook trout has not been reported.

Brook trout interactions with Chinook salmon

No literature on brook trout interactions with Chinook salmon was located. However, brook trout spawn at the same time of the year as Chinook salmon but prefer smaller substrate and small tributaries. Juvenile rearing occurs in similar habitat and because brook trout are piscivores, predation on juvenile Chinook salmon is possible. There are no reports of hybridization between brook trout and Chinook salmon.

Brook trout interactions with green sturgeon

Brook trout use different habitat types than green sturgeon for virtually all life stages. Incidental predation may occur on larval forms of sturgeon during migration. No literature on these species interactions was found.

Brook trout interactions with river lamprey

Brook trout and river lamprey utilize similar spawning habitats, although brook trout are fall spawners while river lamprey are spring spawners. Juvenile lamprey (ammocoetes) remain buried in the mud for two to three years and utilize different resources for rearing. Some predation may occur when ammocoetes emerge from the mud as small adults, although this has not been documented. No literature on these species interactions was found.

Brook trout interactions with hardhead

Brook trout and hardhead utilize similar spawning habitat, but spawning occurs at different times of the year. Juvenile rearing may occur in similar habitat so competition for resources may be a factor, although brook trout tend to remain in colder water than hardhead. Adult brook trout prefer deeper water than juvenile hardhead, but some limited predation may occur. No literature on these species interactions was found.

Brook trout interactions with Sacramento splittail

Brook trout use different habitat types than Sacramento splittail for virtually all life stages. Incidental predation may occur on juvenile splittail during migration. No literature on these species interactions was found.

Coho salmon

California coho salmon generally exhibit a three-year life cycle with about half the time spent in freshwater and half in saltwater (Moyle 2002). Coho salmon from central California enter rivers in late December or January and spawn immediately afterwards (Weitkamp et al. 1995). Coho salmon utilize similar spawning habitat to Chinook salmon and steelhead (Moyle 2002), although smaller tributaries are preferred (DFG 2002b).

In hatcheries, coho salmon eggs hatched in about 38 and 48 days at water temperatures of 51.8 and 48.2^{o}F, respectively (Hassler 1987). After hatching, emergence from the gravel generally occurs in two to seven weeks (Hassler 1987). Juvenile coho salmon show pronounced shifts in habitat with season, especially in California streams (Bell 2001). In winter, juvenile coho salmon select habitats with low water velocity; in spring, juveniles are widely distributed through riffles and runs; in summer, juveniles concentrate in deeper pools or runs (Bell 2001). Juvenile coho salmon tend to rear in cool tributaries in contrast to Chinook salmon which stay in warmer main rivers (Moyle 2002). The diet of juvenile coho salmon consists mainly of aquatic insect larvae and terrestrial insects, although small fish are taken when available (Moyle 2002).

Juvenile coho salmon rear for 12 to 24 months before beginning seaward migration as smolts (Moyle 2002). The majority of coho salmon remain at sea for 16 to 18 months before returning to freshwater to spawn (Moyle 2002). Some males may return as "jacks" after only six months at sea (Moyle 2002).

Coho salmon interactions with steelhead

Coho salmon spawn earlier in the year than steelhead and prefer tributaries to mainstem rivers. Although some spawning may overlap, hybridization between coho salmon and steelhead is not reported in the literature. Juvenile coho salmon occupy similar habitat to steelhead in the spring although smaller tributaries are preferred (Moyle 2002). If resources are scarce, some competition may occur during the spring, although coho salmon and steelhead are sympatric in many Pacific coast watersheds and probably partition resources.

Juvenile coho salmon are known to eat small fish (Moyle 2002). Pearsons and Fritts (1999) found juvenile coho salmon preying on juvenile Chinook salmon up to 47 percent of their length. This size criterion implies juvenile steelhead (age 0) may be preyed on by yearling coho salmon (age 1).

Coho salmon interactions with Chinook salmon

Coho salmon spawn later in the year than Chinook salmon and prefer tributaries to mainstem rivers. Although the timing of spawning is slightly different some overlap may occur. If spawning habitat is limited, some competition could occur although redd superimposition may be more likely. Juveniles rear in similar habitat and if resources are in short supply, some competition could occur.

Pearsons and Fritts (1999) found juvenile coho salmon preying on juvenile Chinook salmon up to 47 percent of their length. This size criterion implies juvenile chinook salmon (age 0) may be preyed on by yearling coho salmon (age 1). Although coho salmon and Chinook salmon are sympatric in many Pacific coastal watersheds, rearing habitat in the Feather River could be limited forcing more encounters between juveniles leading to predation.

There is limited evidence that coho salmon and Chinook salmon may naturally hybridize (Bartley et al. 1990). Bartley et al. (1990) reports that those reputed hybrids found could have been the result of human intervention. In their study, they examined Chinook salmon from different locations in the Trinity Basin of northern California. First generation hybrids were identified in three different locations through genetic detection using allelic products from seven isozyme loci. One of these locations in which hybrids were found was later shown to contain hybrids from an inadvertent cross between coho salmon and Chinook salmon at the nearby Irongate Hatchery. Evidence against naturally occurring hybridization is fairly strong. Utter et al. (1989) as reported *in* Bartley et al. (1990) examined 86 populations of Chinook salmon from the Babine River, British Columbia to the Sacramento River, California using genetic techniques similar to the Bartley study, and found no evidence of coho salmon x Chinook salmon hybridization. Additionally, Bartley et al. (1990), in their review of the literature, were unable to find any documented cases of fertile f_1 female hybrids. This would imply that although hybridization between the species is possible, genetic introgression is not.

Coho salmon interactions with green sturgeon

Coho salmon use different habitat types than green sturgeon for virtually all life stages. Incidental predation may occur on larval forms of sturgeon during out migration of coho smolts. No literature on these species interactions was found.

Coho salmon interactions with river lamprey

Coho salmon and river lamprey utilize similar spawning habitats although coho salmon are fall and winter spawners while river lamprey are spring spawners. Juvenile lamprey (ammocoetes) remain buried in the mud for two to three years and utilize different resources for rearing. Some predation may occur when ammocoetes emerge from the mud as small adults although this has not been documented. Additional predation could occur during coho smolt out migration. No literature on these species interactions was found.

Coho salmon interactions with hardhead

Coho salmon and hardhead utilize similar spawning habitat but spawning occurs at different times of the year. Juvenile rearing may occur in similar habitat so competition for resources may be a factor although coho salmon prefer colder water temperatures for rearing. Limited predation could occur during coho smolt out migration. No literature on these species interactions was found.

Coho salmon interactions with Sacramento splittail

Coho salmon use different habitat types than Sacramento splittail for virtually all life stages. Incidental predation may occur on juvenile splittail during out migration of coho smolts. No literature on these species interactions was found.

Chinook salmon

Because spring-run Chinook salmon and fall-run Chinook salmon are genetically identical as defined by the biological species concept and are historically genetically separated by spatial and temporal differences during spawning, it is possible that genetic introgression between these two races of Chinook salmon could occur in the lower Feather River. Genetic introgression between Chinook salmon races in the lower Feather River is addressed by SP-F9 and its associated study plan reports.

5.2 NON-STOCKING RELATED MANAGEMENT ACTIVITIES

Non-stocking related management activities in the project area include both habitat enhancement projects and genetic enhancement activities. Habitat enhancement projects include the anchoring of structures in Lake Oroville to provide cover for juvenile black bass. Genetic enhancement activities include the introduction of different strains of warmwater fish to promote a trophy recreational sport fishery.

5.2.1 Habitat enhancements

Because Lake Oroville's water level fluctuations and poor soils hinder the establishment of aquatic plants, DWR has implemented a program for aquatic habitat improvements (DWR 2001). This habitat improvement plan was implemented in 1995 and completed in the spring of 2000. DWR has proposed continuation of these activities through 2004 (DWR 2001). Habitat improvements consist primarily of providing cover for juvenile black bass in Lake Oroville. Habitat enhancement projects have included installing Christmas tree brush shelters, installing manzanita brush shelters, and the planting of Button Brush and willow trees (DWR 1999). It is conceivable that a significant flood event could cause the transport of debris from these structures to the Feather River; however, because these structures are anchored, this scenario is highly unlikely.

There have also been some experimental structures placed in the lake to improve channel catfish spawning habitat. These structures utilize rocks or existing woody debris found along the shore of the lake. Most of these structures are approximately 30 inches (76 cm.) long, 20 inches (51 cm) wide, and 10 inches (25 cm) deep (DWR 1997).

5.2.2 Genetic Enhancements

The warmwater fishery in Lake Oroville is self-reproducing and, therefore, is not stocked in order to maintain a viable fishery; management activities targeting the warmwater fishery are designed to promote genetic enhancements of sport fish. Genetic enhancement experiments have included the planting of Florida strain largemouth bass for trophy fish promotion. It has been reported that Florida strain largemouth bass show a superior growth rate, longer life span and a decreased susceptibility to angling pressure (Forshage and Fries 1995). Some warmwater fish including largemouth bass (Seesholtz et al. 2003) have been captured in the Feather River, suggesting a potential for interaction between genetically enhanced fish in the project area and native fish species of concern in the Feather River.

6.0 ANALYSES

6.1 STOCKING RELATED MANAGEMENT ACTIVITIES

6.1.1 Potential for disease transmission

Disease transmission does not necessarily require direct contact among individuals of the same or different species; hence, the requirement for individuals of the same or different species to be present at the same time and place may not exist. In some cases, pathogens from fish infected with a particular disease could be transported via normal facility operations, even if the infected fish is not transported from one location to another. In these cases, a disease outbreak in the Feather River Hatchery could result in release of infected water to the Low Flow Channel of the Feather River. To avoid this possibility, water from the hatchery is diverted to a settling pond (DWR 2002c).

A review of the literature does not indicate that disease transmission from hatchery-reared fish to wild fish presents a problem, in general, as long as standard hatchery disease prevention and mitigation protocols are followed. These protocols include proper disinfection procedures, periodic examinations by a fish pathologist, and use of certified disease free coho eggs. Steward and Bjornn as reported in Perry (1995) concluded that, "in spite of the comparatively high incidence of disease among some hatchery fish stocks, there is little evidence to suggest that diseases or parasites are routinely transmitted from hatchery fish to wild fish."

The Feather River Hatchery is operated by DFG and maintained by DWR. USFWS provides advice for ongoing operations including disease control and mitigation. In 2000, the Feather River Hatchery upgraded incubation facilities to include equipment for ultraviolet sterilization of a portion of the incoming water supply to minimize infection of eggs and developing juvenile fish. Water exiting the hatchery facility is directed to a settling pond to prevent the discharge of infected water to the Feather River (DWR 2002c). At the Feather River Hatchery, regularly scheduled examinations by a fish pathologist serve to monitor developing embryos and fish health. These improvements and examinations should serve to keep fish raised at the Feather River hatchery disease-free, and should also serve to identify disease outbreaks prior to stocking, should they occur.

IHN outbreaks at the Feather River Hatchery in 1998, 2000, and 2001 caused DWR to re-evaluate stocking practices in Lake Oroville. The IHN outbreaks resulted in significant mortality at the Feather River Hatchery. In 1998, 2000, 2001 and 2002, several million juvenile Chinook salmon died or had to be destroyed as a result of IHN (DWR 2003b). Since 2000, IHN concerns have halted the stocking of Chinook salmon and brown trout in Lake Oroville. DFG fish pathologists examined several species of salmonids and concluded that coho salmon were the least susceptible to IHN (DWR 2003b). Based on this evaluation, the stocking plan used for Chinook salmon stocking in Lake Oroville was adapted for stocking of coho salmon in Lake Oroville, as detailed above. This plan will remain in effect until 2007.

Provided that standard hatchery disease prevention and mitigation protocols are followed, including proper disinfection procedures, periodic examinations by a fish pathologist, and use of certified disease free coho salmon eggs, the stocking of disease-free coho salmon in Lake Oroville would not be expected to result in increased transmission of IHN to wild Feather River salmonids, including ESA-listed Chinook salmon and steelhead. The disease screening procedures currently in use in the Feather River Hatchery have ensured that previous hatchery outbreaks of IHN have not resulted in large-scale outbreaks in the in-river Chinook salmon and steelhead populations, and such procedures should continue to prevent IHN-infected stocked salmonids (including coho salmon) from being stocked in any project waters, thus limiting the effect of stocking activities on IHN transmission to in-river salmonids populations.

C. shasta, the parasite that causes ceratomyxosis, is endemic to the Feather River watershed and native salmonids have developed resistance to the infection. Therefore, it does not appear that stocking of *C. shasta*-sensitive salmonids poses a significant threat to native salmonids in the Feather River. *C. shasta* infections, which are particularly lethal to many strains of stocked rainbow trout, may in fact reduce the likelihood of other interactions between stocked rainbow trout and Feather River native salmonids, due to mortality of the stocked fish. Because rainbow trout stocked in the Thermalito Forebay target a put-and-take fishery, long-term survival of these fish is not desired. Typically trout die within three months of infection with *C. shasta* (Noga 1996). Because native salmonids are resistant to *C. shasta*, stocking of *C. shasta*-sensitive salmonids, such as rainbow trout, would not be expected to result in increased transmission of *C. shasta* to wild Feather River salmonids, including ESA-listed Chinook salmon and steelhead.

Cold water disease, BKD and Whirling disease are the other diseases of concern in the project area. All of the disease agents causing these diseases are endemic to waters in the Feather River watershed and, therefore, native fish species are exposed to these diseases and disease agents regardless of fish stocking strategies. Normal hatchery operating procedures should minimize the potential for additional spread of the pathogens causing these diseases to wild stocks from hatchery stocks. There are well-documented procedures for controlling cold water disease outbreaks in hatcheries, and the Feather River Hatchery maintains a separate facility on the west side of the Thermalito Afterbay to raise Chinook salmon that are particularly sensitive to the disease. BKD is a widespread, chronic problem in freshwater environments. Hatchery procedures should limit hatchery outbreaks of BKD, thereby limiting the chance of increasing the incidence of BKD in native salmonids. USFWS at the National Workshop on Bacterial Kidney Disease in Phoenix, AZ. in 1991 stated, "there is no reason to destroy stocks of fish that are infected with *R. salmoninarium*" and, "If *R. salmoninarium* is present at any broodstock facility, the stocks should be managed to reduce the severity of infection and if necessary the fish should be stocked only in areas where the pathogen is present." Normal hatchery precautions, including the rearing of fish in concrete raceways, also minimize the chance of infection with whirling disease. To date, although the parasite causing Whirling disease has been found in California waterways, including the Feather River, no adverse effects on native salmonid populations have been observed, as reported in SP-F2, indicating that existing hatchery procedures minimize the chance of increasing the incidence of Whirling disease in native salmonids.

Overall, diseases of concern are generally endemic to the Feather River watershed, resulting in some level of exposure to native salmonids. However, because of standard hatchery disease prevention and mitigation protocols and special protocols and facilities for controlling particularly threatening diseases, stocking activities are not likely to substantially increase the incidence of disease in wild fish populations above the existing disease baseline which exists due the endemicity of the disease agents in the watershed.

6.1.2 Potential for competition, predation and genetic introgression

For competition, predation, or genetic introgression to occur, hatchery raised fish and listed species in the Feather River must overlap both temporally and spatially. For any of these interactions to occur, stocked fish must escape the reservoir environment and emigrate to the lower Feather River.

6.1.2.1 Opportunities for fish in Lake Oroville to pass downstream

In order for fish planted in Lake Oroville to reach the Feather River, they would have to pass over the Oroville Dam Spillway or through the Edward Hyatt Power Plant. Passage over the spillway could occur in one of two ways, either through the gated control structure or through the emergency uncontrolled spillway. It is possible that significant flood events could allow passage of fish over the spillway; however, only five of these flood events have been recorded since 1970 (DWR 2001). Another potential way for fish to pass from Lake Oroville to the Feather River would be passage through the turbines at the Edward Hyatt Powerplant (Figure 6.1-1).

Those fish that transit the Oroville Dam must then either pass through the Thermalito facilities, entering the Thermalito Power Canal at the Thermalito Diversion Dam, or pass through or over the Thermalito Diversion Dam. Transit of the Thermalito Diversion Dam would require passing over the spillway into the Low Flow Channel of the Feather River or passing through the turbines of the Thermalito Diversion Dam Powerplant into the Low Flow Channel. Finally, those fish must then pass over the Fish Barrier Dam located upstream from the Feather River Hatchery.

Relatively little specific information regarding passage of fish planted in Lake Oroville to the Feather River is available. However, data collected in one study can specifically be used to evaluate fish passage from Lake Oroville to the Feather River. From 1992 through 1997, 4312 Chinook salmon stocked in Lake Oroville were tagged with $10 reward tags. In 1991 and 1993, 1398 stocked brown trout were also tagged with $10 reward tags. Of these tagged fish, 9 Chinook salmon and 4 brown trout were captured in the Feather River (Eric See, DWR, Pers. Comm.) as cited in Study Plan SP-F5/7. Therefore, it is possible for fish stocked in Lake Oroville to escape the lake via one of the routes described above.

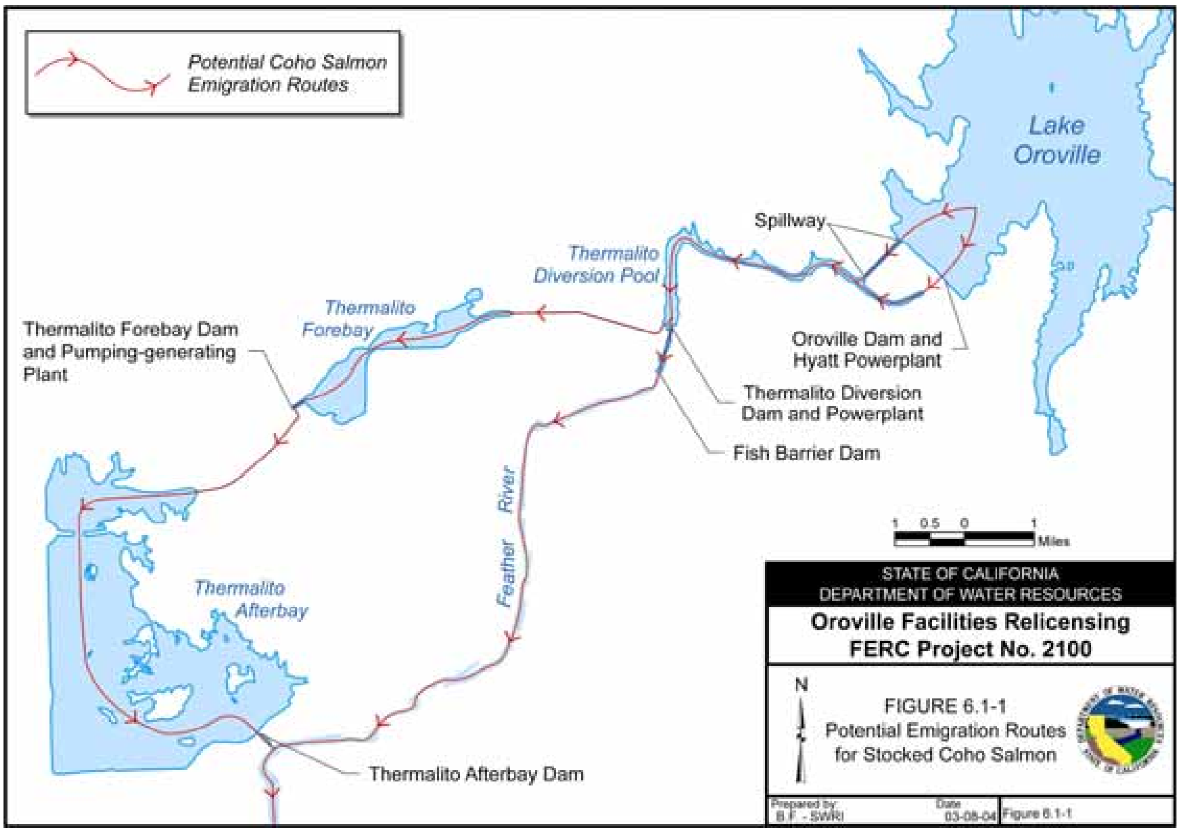

Figure 6.1-1. Map of Oroville Facilities showing potential emigration routes for stocked coho salmon.
Source (DWR 2002d)

6.1.2.2 Opportunities for fish in Thermalito Forebay to pass downstream

There are two possible passage routes for fish in the Thermalito Forebay to pass to the Feather River. The first route would involve travel through the Thermalito Power Canal to the Thermalito Diversion Pool, followed by a downstream transit of the Thermalito Diversion Dam and then over the Fish Barrier Dam. The second route would be downstream passage through the Thermalito Pumping-generating Plant into the Thermalito Afterbay followed by passage through the Thermalito Afterbay Outlet (Figure 6.1-2).

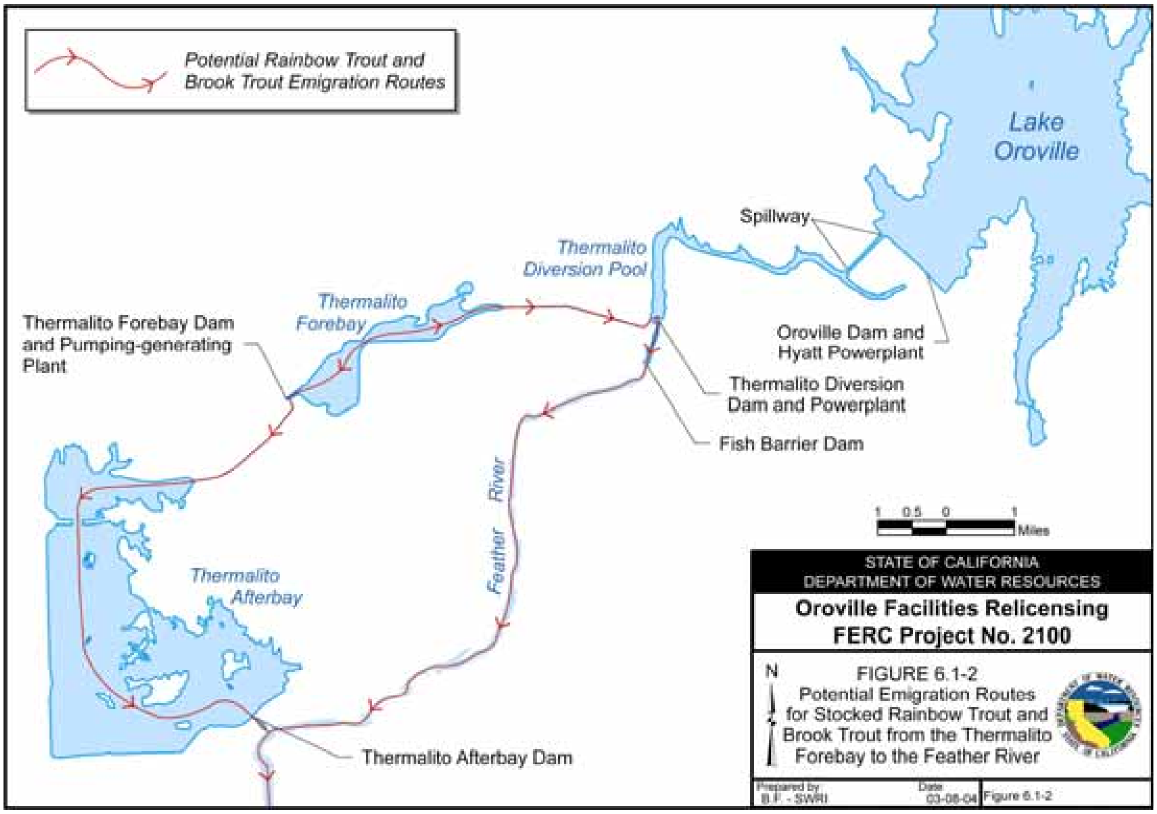

Figure 6.1-2. Map of Oroville Facilities showing potential emigration routes for stocked rainbow trout and brook trout from the Thermalito Forebay to the Feather River.
Source (DWR 2001)

6.1.2.3 Rainbow Trout

Rainbow trout stocked in the Thermalito Forebay are subject to intense angling pressure. In most cases it can be anticipated that anglers will catch 80 to 90 percent of these fish (Wiley 1995). Additionally, the stocks of rainbow trout planted in the Thermalito Forebay are not indigenous to the area and are highly susceptible to ceratomyxosis, a nearly 100 percent fatal disease, with death occurring within three months of initial infection (Noga 1996). Therefore, very few rainbow trout would be expected to survive angling pressure, transit, and disease in order to potentially interact with ESA- and SSC-listed fish species in the Feather River.

Although very few rainbow trout stocked in the Thermalito Forebay would be expected to survive the combination of angling pressure, transit, and disease required to successfully pass to the mainstem Feather River, the few rainbow trout that may pass to the mainstem Feather River have the potential to interact with steelhead or Chinook salmon populations in the Feather River. However, McMichael et al. (1997) found that even significant numbers of hatchery released steelhead (rainbow trout) had no discernable effect on wild Chinook salmon juvenile populations in the Tenaway River in

Washington. This suggests different microhabitat preferences between the two species further minimizing the potential for interaction. Predation and competition interactions with wild steelhead are not likely due to the small numbers of hatchery rainbow expected to be in the system.

Stocked rainbow trout also present a potential source for nonspecific genetic introgression with wild steelhead in the Feather River. Leary et al. (1995) suggest that a one percent or less level of foreign genes in the population is unlikely to alter the biological characteristics of a fish population from those of the native taxon. Based on the limited observational data presented above, it is not expected that a sufficient number of hatchery rainbow trout survive the intense angling pressure, the incidence of disease and the pressures of transit to exceed Leary's one percent threshold. Hybridization between Chinook salmon and steelhead has not been reported in the literature.

Stocked rainbow trout that escape the reservoir and survive disease also have a potential to interact with non-salmonid fish species of concern. Because they are not closely related, stocked salmonids such as rainbow trout would not be expected to be a source for genetic introgression with native non-salmonids in the Feather River. Distributions of non-salmonid fish species were evaluated in SP-F3.2 Task 1 and SP-F21 Task 2. Interactions with Sacramento splittail are not likely because they typically inhabit warmer waters in the lower portion of the Feather River downstream from the confluence of Honcut Creek, whereas rainbow trout would be expected to reside in cooler waters upstream from the Thermalito Afterbay Outlet. Likewise, green sturgeon are generally distributed downstream from the Thermalito Afterbay Outlet as described in the SP-F3.2 Task 1 report. The occurrence of both Sacramento splittail and green sturgeon is described as infrequent. River lamprey have been observed upstream from the Thermalito Afterbay Outlet but their occurrence is also described as infrequent in the SP-F3.2 Task 1 report. Additionally, juvenile rearing of river lamprey occurs in a different habitat type than that in which rainbow trout would be expected. Hardhead, although placed on the California Species of Concern Watch List, are fairly common in the Feather River from the Fish Barrier Dam downstream to the confluence with the Sacramento River. Juvenile hardhead also prefer a different habitat type than rainbow trout so potential interactions would be further limited. In summary, the few rainbow trout that would be expected to escape the Thermalito Forebay would not be expected to have any significant impact on these non-salmonid species.

6.1.2.4 Brook Trout

Like rainbow trout, very few brook trout have been observed in the Feather River. In over three years of fish collection in the lower Feather River using seining techniques and rotary screw traps, Seesholtz et al. (2003) only recorded a single capture of one brook trout. Brook trout are subject to the same intense angling pressure as rainbow trout in the Thermalito Forebay put-and-take fishery. Brook trout are also susceptible to *C. Shasta* infections, although to a lesser extent than rainbow trout (Noga 1996).

Brook trout could potentially prey on young Chinook salmon, as the larger brook trout would tend to occupy similar habitat. However, because so few brook trout have been observed in the Feather River, neither competition nor predation is likely to be a factor in juvenile Chinook salmon or juvenile steelhead survival. Likewise, brook trout are not likely to negatively impact non-salmonid species of concern in the Feather River.

6.1.2.5 Coho Salmon

Coho salmon are currently stocked in Lake Oroville. DWR and DFG reports show that in the past, some Chinook salmon stocked in Lake Oroville successfully pass from the lake to the Feather River. The most likely scenario for significant numbers of fish to escape the lake would be during a high water event in the spring when the emergency spillway is used. However, these high water events do not occur frequently enough to allow significant numbers of coho salmon to escape. Additionally, coho salmon selected for the Lake Oroville stocking program are a domesticated variety, selectively bred for rapid growth and high survival in aquaculture facilities. They have a two-year life cycle and exhibit less of a propensity to migrate than their wild counterparts (DFG 2001b).

It should also be noted that wild steelhead, coho salmon, and Chinook salmon are sympatric in many Pacific Coast watersheds. This suggests that they utilize different microhabitats within the system and direct interactions would be limited. The evidence for intra-specific hybridization between coho salmon and Chinook salmon is weak. Those few coho salmon that do manage to escape the reservoir and then return to the Feather River to spawn are not likely to have any effect on the naturally spawning Chinook salmon population. Several thousand Chinook salmon spawn in the Feather River on an annual basis. Any potential hybridization events between adult coho salmon and spawning Chinook salmon would be expected to be well below the Leary et al. (1995) one percent threshold.

Because juvenile coho salmon utilize different resources at different times than the non-salmonid species of concern in the Feather River, competition with those non-salmonid species of concern would not be expected even if coho salmon escaped Lake Oroville. Predation on these same species would be limited to juveniles and it is not likely that coho salmon would escape frequently enough to become a predation threat to non-salmonid species of concern.

6.2 NON-STOCKING MANAGEMENT ACTIVITIES

Non-stocking management activities in the project area primarily consist of habitat enhancements in Lake Oroville and genetic enhancements to fish comprising the warm water fishery. Habitat enhancements that have been implemented under the Habitat Enhancement Program consist of structures providing cover for juvenile black bass. These structures are made from Christmas trees and manzanita bushes anchored to the lake bottom, and willow trees and Button Brush are also planted in Lake Oroville. These structures are unlikely to have any impact on downstream fish species.

Genetic enhancements targeting the warm watery fishery are spatially separated from the Feather River. Those few enhanced warm water fish that manage to escape the reservoir are likely to reside in the Feather River downstream from the Thermalito Afterbay Outlet where water temperatures are more suitable. Native salmonid juveniles in the project area are found almost exclusively upstream from the Thermalito Afterbay Outlet where water temperatures are cooler. During snorkeling surveys conducted in 1999, 2000, and 2001, less than one percent of young of the year steelhead were observed downstream from the Thermalito Afterbay Outlet (DWR, unpublished data).

Non-salmonid fish species of concern could be adversely affected by significant numbers of warmwater fish escaping the reservoirs. As an example, largemouth bass are known to be significant predators on hardhead (Moyle 2002). However, it is not expected that sufficient numbers of largemouth bass would escape from Lake Oroville to present a predation threat to the rather numerous juvenile hardhead.

Because non-stocking management activities are confined to the reservoirs, it is not anticipated that these activities would impact downstream habitat or fish species of concern in the Feather River. Habitat improvements are of a localized nature while genetic enhancements to existing fish stocks are directed towards non-migratory species.

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