State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
FISH SPECIES COMPOSITION AND JUVENILE BASS RECRUITMENT IN THE THERMALITO AFTERBAY
SP-F3.1 TASK 4A

Oroville Facilities Relicensing
FERC Project No. 2100

December 2004

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REPORT SUMMARY

The purpose of SP-F3.1 Task 4A was to describe the fish species composition and to evaluate juvenile bass recruitment in the Thermalito Afterbay. Operation of the Oroville Facilities creates a complex hydrological regime in the Thermalito Afterbay, which has the potential to influence both the fish species composition and juvenile bass recruitment. Operation of the Oroville Facilities affects the quantity and quality of fish habitat through frequent water level and water temperature fluctuations. The Thermalito Afterbay has multiple outlets that deliver water to several different agricultural canals and to the lower Feather River. Water from the Thermalito Afterbay also is used during pump-back operations. The shallow nature of the Thermalito Afterbay results in substantial changes in the amount of available littoral habitat with only small surface elevation changes. The results of this study provide information regarding fish species composition and juvenile bass recruitment in the Thermalito Afterbay. Additionally, the results of this study will be used to evaluate effects of potential Resource Actions or changes in operations that may influence surface elevation fluctuations on the current fish species assemblage in the Thermalito Afterbay.

Because limited fish sampling was conducted in the Thermalito Afterbay, determination of the fish species composition is largely based on angler surveys conducted from September 2000 through August 2003 and electrofishing surveys conducted during November 2002 and April 2003. Additionally, during May and June 2003, snorkeling surveys were conducted in suspected bass spawning areas. Results of these surveys and incidental observations were used to develop a list of fish species found in the Thermalito Afterbay. Observations of bass nest de-watering, combined with records of surface elevation fluctuations, provided the only quantitative data available to estimate juvenile bass recruitment. Insufficient quantities of data or small numbers of observations were available to conduct a quantitative analysis of juvenile bass recruitment based on juvenile-to-adult ratios. Instead, data on water surface elevation fluctuations, combined with a review of available fisheries literature, were used to provide a qualitative assessment of juvenile bass recruitment in the Thermalito Afterbay.

Fish species observed in the Thermalito Afterbay included Largemouth bass (*Micropterus salmoides)*, smallmouth bass (*M. dolomieui*), spotted bass (*Micropterus punctulatus*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook trout (Salvelinus fontinalis), bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), black crappie (*Pornoxis nigromaculatus*), channel catfish (*Ictalrus punctatus*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), hitch (*Lavinia exilicaudia*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), sculpin (*Cottus sp.*), and wakasagi (*Hypomesis nipponensis*). Salmonids have not been stocked in the Thermalito Afterbay and salmonid spawning in tributaries of the Afterbay is unlikely due to limited habitat availability. Rainbow trout, brook trout, and brown trout present in the afterbay likely passed through the Thermalito Pumping-Generating Plant from the Thermalito Forebay.

Based on a review of available literature, the Thermalito Afterbay likely provides appropriate habitat for black bass species, and large schools of wakasagi likely provide a source of forage fish. The Final Report for SP-F3.1 Task 4C provides the analysis of bass nest dewatering in the Thermalito Afterbay. Based on four years of water surface elevation fluctuation data, it appears that bass nest dewatering would have a minimal effect on spotted bass, an intermediate effect on smallmouth bass, and a substantial negative effect on largemouth bass. Bass nest de-watering is probably the limiting factor in juvenile recruitment. However, good habitat, a strong forage fish base, and low angler harvest rates due to large amounts of aquatic vegetative cover may offset negative factors associated with nest dewatering. Additionally, the complex thermal regime in the afterbay could potentially positively or negatively affect juvenile bass recruitment. Warmer water temperatures cause the onset of spawning behavior and decrease the duration of embryo incubation, while cooler water temperatures inhibit spawning behavior and increase the duration of embryo incubation. The constantly changing thermal environment within the afterbay could alter spawning behavior and incubation duration such that it benefits or is detrimental to juvenile bass recruitment.

Based on the analysis contained in this report, it is likely that black bass populations in the Thermalito Afterbay will persist unless changes in operations create additional water surface level or water temperature fluctuations during the black bass spawning and embryo incubation period, which occurs from April through June for smallmouth and spotted bass and from March through June for largemouth bass.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

The Oroville Facilities have the potential to influence fish species composition and juvenile bass recruitment in the Thermalito Afterbay due to frequent surface elevation fluctuations and water temperature changes caused by project operations. Water surface elevation can fluctuate rapidly and frequently due to the Thermalito Afterbay's high surface to volume ratio and the nature of afterbay operations. When the Thermalito Afterbay fluctuates on a weekly scale, the reservoir is typically maintained at low water surface levels in the beginning of the week, and as power is generated through the Thermalito Pumping-Generating Plant, the reservoir is filled. By the end of the week, the reservoir water surface elevation is typically high and is drawn down over the weekend. The water level fluctuation in the Thermalito Afterbay may impact warmwater fish by dewatering bass nests and forcing juveniles to move from protective cover, exposing them to a greater risk of predation. Additionally, water temperature fluctuations could alter adult bass spawning behavior and embryo incubation duration potentially altering nest success. As a component of study plan (SP) – F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area,* Task 4A, herein describes the fish species composition in the Thermalito Afterbay and evaluates project effects on juvenile bass recruitment.

1.1.1 Statutory/Regulatory Requirements

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 (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact from on-going and future operations. As a subtask of SP-F3.1, Task 4A fulfills a portion of the FERC application requirements by describing the fish species composition and by detailing potential effects of project operations juvenile bass recruitment in the Thermalito Afterbay.

1.1.2 Study Area

The study area for this report is limited to the Thermalito Afterbay.

1.1.2.1 Description

The Thermalito Afterbay is a large, shallow off-stream reservoir with a high surface-to-volume ratio and frequent water surface elevation fluctuations. Located approximately six miles southwest of the City of Oroville, the Thermalito Afterbay provides storage for water required by pump-back operations to Lake Oroville. In addition, the Thermalito

Afterbay helps regulate the power production system, produces controlled flows in the Feather River downstream from the Oroville-Thermalito facilities, and provides recreation opportunities including limited sport fishing opportunities. A map of the Thermalito Afterbay is shown in Figure 1.1-1.

The Thermalito Afterbay holds a maximum of 57,040 acre-feet of water. The water surface elevation and water surface area at maximum operating storage are 136.5 feet and 4,300 acres, respectively. The shoreline covers approximately 26 miles at maximum operating storage (DWR 2001). The Thermalito Afterbay has a complex hydrologic regime due to the variable timing of pump-back operations and the heterogeneous hydrogeomorphology of the reservoir (DWR 2001). Water surface elevations can fluctuate rapidly and frequently in the Thermalito Afterbay resulting in a high degree of variability in water levels from day-to-day, and from week-to-week, depending on project operations. During periods when operation of the Thermalito Afterbay causes weekly fluctuations, the reservoir level is lowered in the beginning of the week to accommodate power generation needs toward the end of the week. As power generation needs increase, the Thermalito Pumping-Generating Plant generates power as the Afterbay fills. Therefore, by the end of the week, the reservoir surface elevation is relatively high. Over the weekend the reservoir is drawn down to provide storage capacity for the following week, allowing the cycle to repeat (pers. comm., See 2003b). No pump-back operations occurred during the spring and summer of 2003 (pers. comm., See 2003c).

1.1.2.2 History

Thermalito Afterbay fisheries management has been conducted by DFG based on general rules and regulations applicable to California lakes and reservoirs. Limited fish stocking has occurred in the Thermalito Afterbay including 250,500 rainbow trout (*Oncorhynchus mykiss*) in 1968, 2,500 striped bass (*Morone saxatilis*) in 1981 and 5,992 channel catfish (*Ictalrus punctatus*) in 1983. Some limited habitat improvement programs have also been implemented including riparian and aquatic vegetation management and bass and catfish spawning habitat enhancements.
The diverse temperature structure of the Thermalito Afterbay provides suitable habitat for both coldwater and warmwater fish species. A popular largemouth bass fishery currently exists and large trout are sometimes caught near the inlet. No salmonid stocking currently occurs in the Thermalito Afterbay, so salmonids caught most likely passed through the Thermalito Pumping-Generating Plant from the Thermalito Forebay (DWR 2001).

Due to economic conditions in California during 2003, no pump-back operations were conducted at the Thermalito facilities resulting in few surface elevation fluctuations compared to normal operating years, which resulted in some increases in water reside times in the Thermalito Afterbay. The shoreline conditions available to the 2003-year class were not analogous to those available to previous year classes. It is likely that a lack of pump-back operations in the spring and summer 2003 resulted in more available habitat in the littoral habitat zone of the Thermalito Afterbay than in other years.

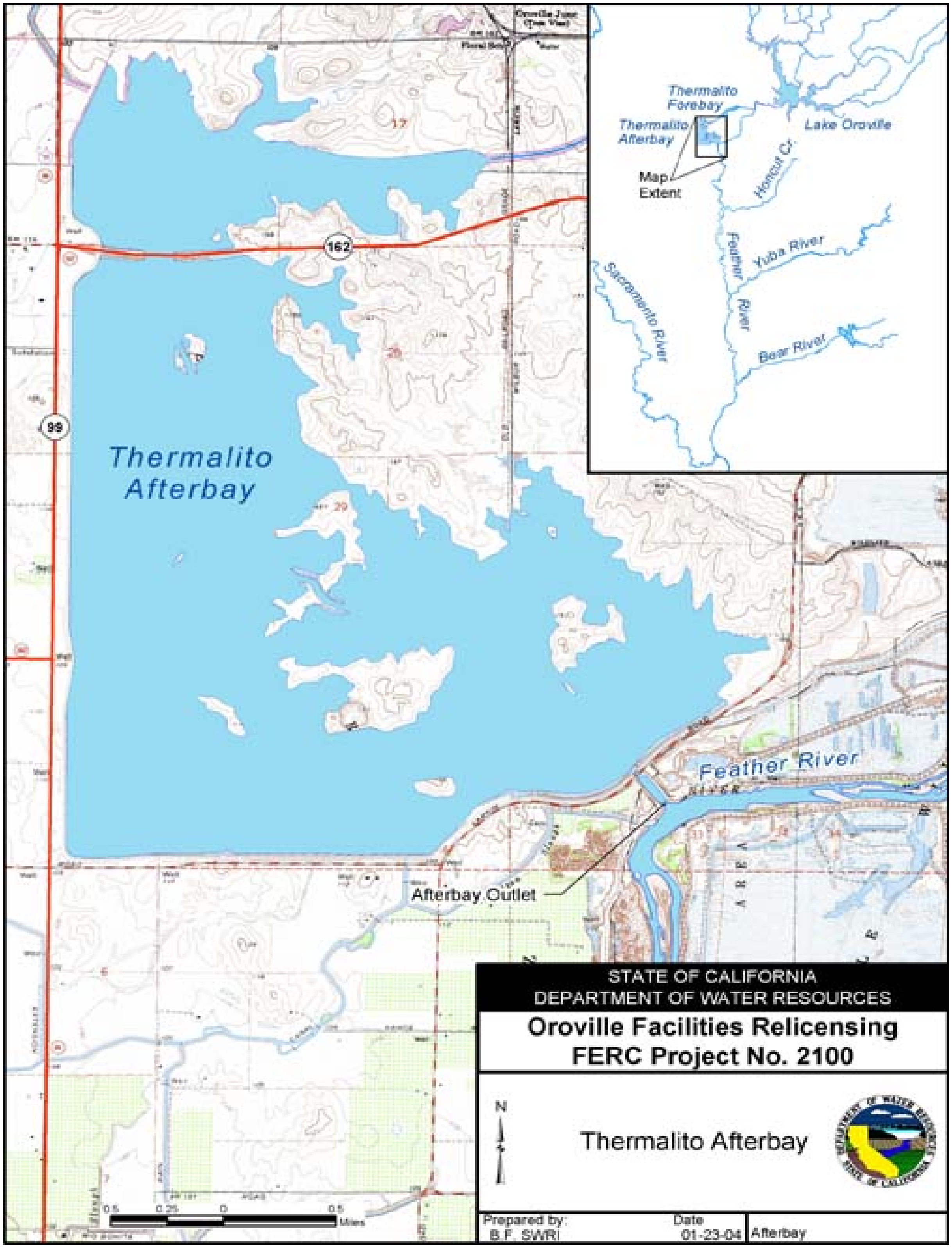

Figure 1.1-1 Thermalito Afterbay

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.

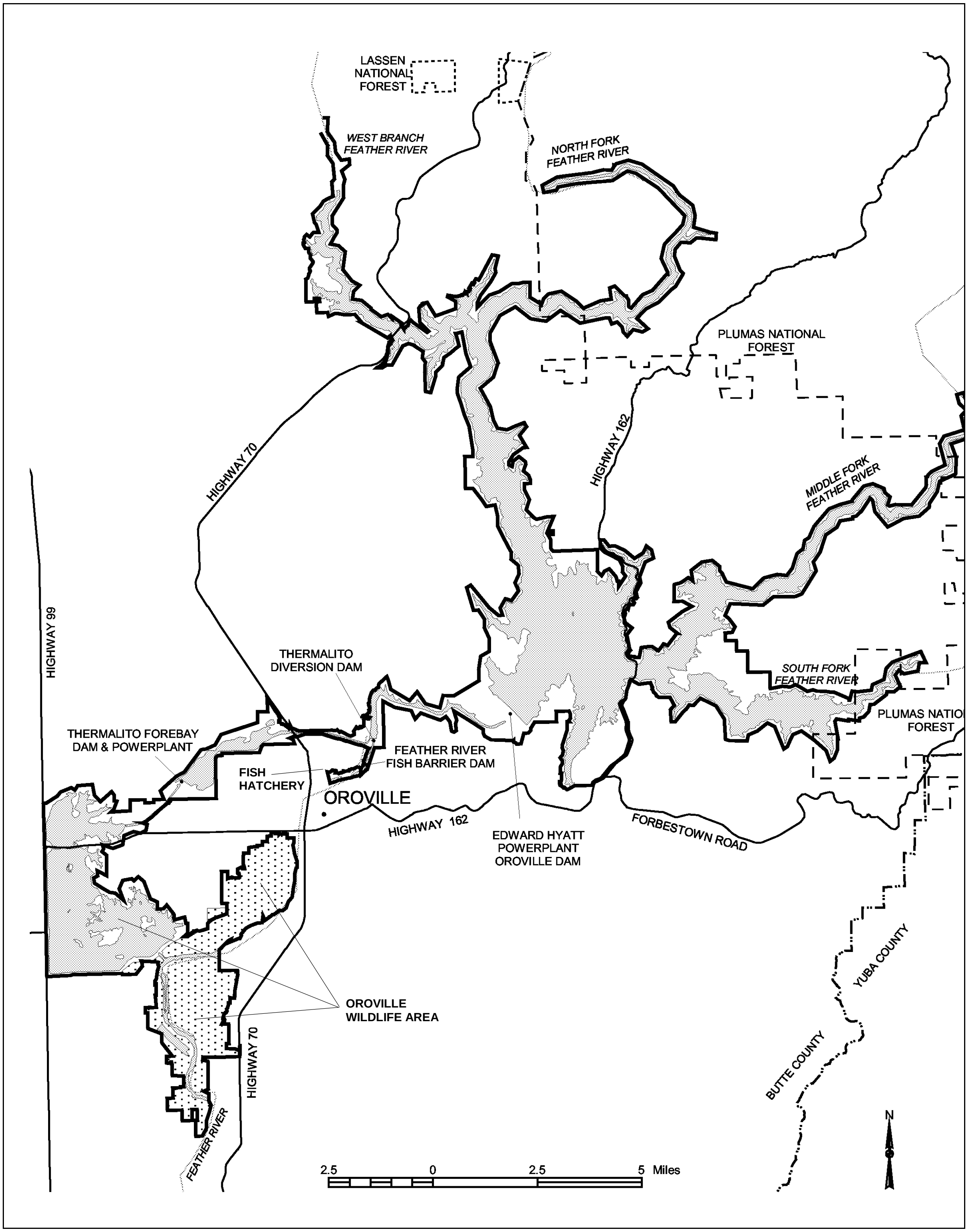

Figure 1.2-1. Oroville Facilities FERC Project Boundary.

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 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 Water 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. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service 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 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 4A is a subtask of SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*. Task 4A fulfills a portion of the FERC application requirements by evaluating fish species composition and juvenile bass recruitment in the Thermalito Afterbay. 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 may affect the species composition and juvenile bass recruitment in the Thermalito Afterbay. Project operations have the potential to affect species composition and juvenile bass recruitment through the timing and range of reservoir surface elevation and water temperature changes.

3.0 STUDY OBJECTIVE

The objective of SP-F3.1 Task 4A was to describe the fish species composition and juvenile bass recruitment in the Thermalito Afterbay and provide information relevant to evaluating the effects of project operations on those species and on juvenile bass recruitment. Information obtained in this study is associated with, and will be applied to the following purposes and activities.

3.1 APPLICATION OF STUDY INFORMATION

The results of this analysis will be used to describe the fish species composition and juvenile bass recruitment in the Thermalito Afterbay and to evaluate the effects of project operations on fish species composition and juvenile bass recruitment.

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 on-going effects of project operations by describing the fish species composition and juvenile bass recruitment in the Thermalito Afterbay. Additionally, information provided in this task will serve as a foundation for future evaluation and development of potential Resource Actions.

3.1.2 Other Studies

As a subtask of study plan SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, Task 4 characterizes project operations associated with the Thermalito Afterbay. Task 4A, herein, describes the fish species composition and juvenile bass recruitment, Task 4B Characterizes the coldwater pool availability, and Task 4C evaluates the magnitude of bass nest de-watering. For further description of Tasks 4B or 4C see SP-F3.1 Task 4 and associated interim and final reports.

3.1.3 Engineering Exhibits

No modeling results from DWR's Engineering and Operations Group were necessary to complete this study plan report because the focus of SP-F3.1 Task 4A, Fish Species Composition and Juvenile Bass Recruitment in the Thermalito Afterbay, is not an operational variable that is being modeled by DWR's Engineering and Operations Group.

3.1.4 Environmental Documentation

In addition to Section 4.51 (f)(3) of 18CFR, which requires reporting of certain types of information in the Federal Energy Regulatory Commission (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 Endangered Species Act (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.

3.1.5 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F3.1 Task 4A provides information that may be useful in the development of potential Resource Actions to be negotiated during the collaborative process.

4.0 METHODOLOGY

Fish species composition of the Thermalito Afterbay was determined through a combination of snorkel surveys conducted in 2003 and electrofishing surveys conducted in November 2002 and April 2003. Sufficient data for a quantitative assessment of juvenile bass recruitment was not obtained. Therefore, a qualitative evaluation of juvenile bass recruitment was completed based on the analysis of bass nest de-watering completed as part of SP-F 3.1 Task 4C, and a review of available literature on black bass life history.

4.1 FISH SPECIES COMPOSITION SURVEYS

Boat electrofishing was conducted at four different locations in the Thermalito Afterbay on November 21, 2002 and at two locations on April 16 and 17, 2003. In addition to the electrofishing surveys, snorkel surveys were conducted on May 1, May 14, May 22, and June 2, 2003 of known or suspected bass spawning areas on the north and south sides of Hwy 162. Snorkel survey locations are shown in Figure 4.1-1. The purpose of the snorkeling surveys was to evaluate black bass nesting. Although the purpose of the snorkel surveys was not to determine fish species composition, fish species observations from these surveys were incorporated into the species composition lists due to the limitations of other available data. Results of angler surveys conducted from September 2000 through August 2003 were also incorporated into the species list to characterize the fish species present in the Thermalito Afterbay. Beach seining and gill netting were also attempted as sampling methods, but neither strategy produced usable results due to limitations of the method and incompatibility with site conditions, e.g. heavy aquatic vegetation, and fish species behavior, e.g. open water net avoidance.

4.2 FISHERIES MANAGEMENT AND HATCHERY OPERATIONS

No direct fisheries management efforts such as fish stocking or implementation of special regulations are currently applied to the Thermalito Afterbay. Current afterbay fisheries management is based on general DFG rules and regulations applicable to California lakes and reservoirs. Catchable-sized brook trout and rainbow trout are stocked in the Thermalito Forebay and some of these fish likely migrate through the Thermalito Pumping-Generating Plant into the Thermalito Afterbay, providing a limited coldwater fishery.

4.3 JUVENILE BASS RECRUITMENT

The original intent of this portion of the study plan was to assess juvenile bass recruitment by determining the ratio of juvenile black bass to adults. After this ratio was determined, similar ratios in lakes and reservoirs with productive bass fisheries would be compared and an assessment made comparing the Thermalito Afterbay to other black bass fisheries. However, available data did not provide adequate sample sizes sufficient to conduct this type of analysis.

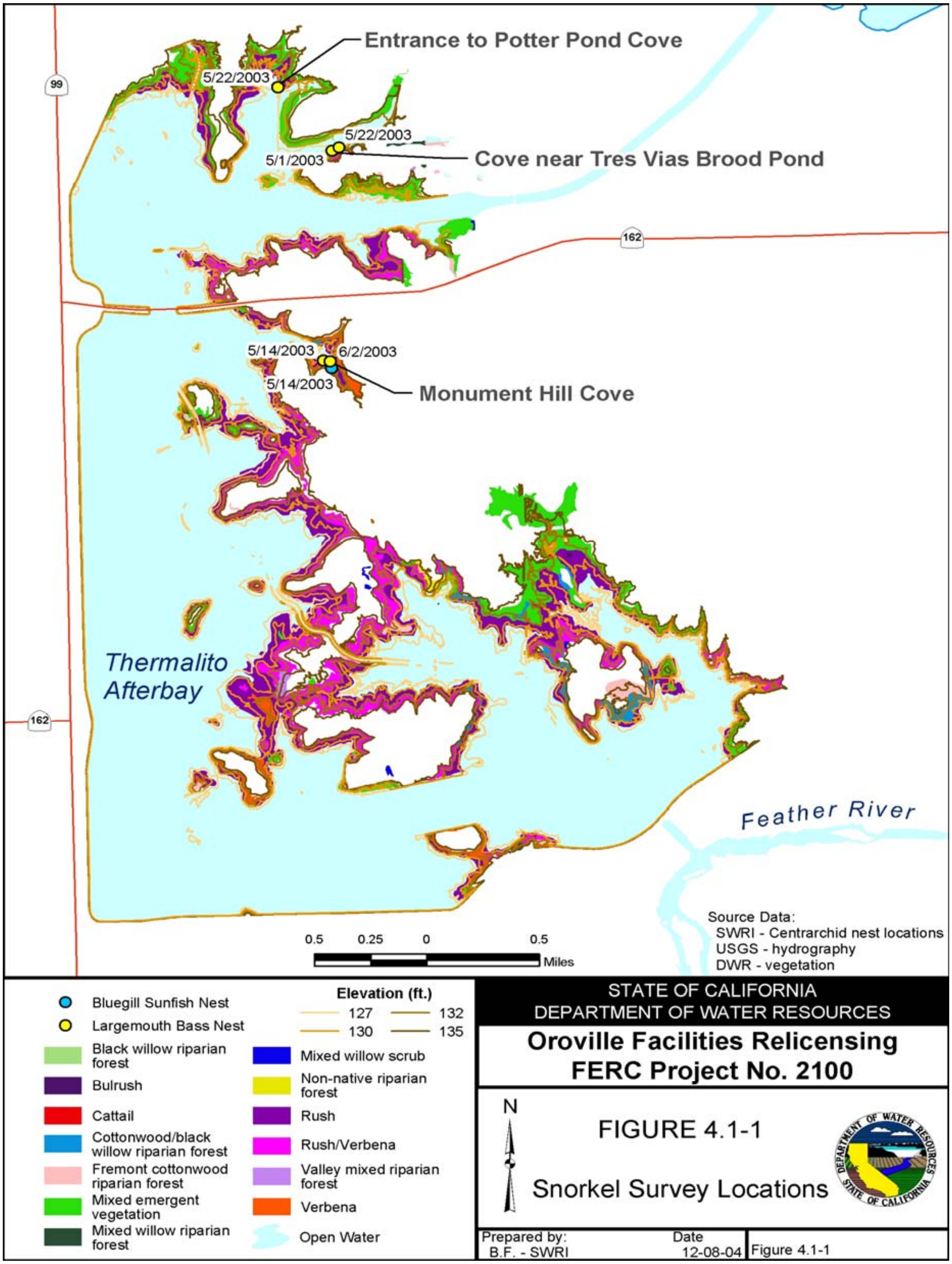

Figure 4.1-1 Thermalito Afterbay Snorkel Survey and Vegetation Locations

Juvenile bass recruitment was assessed qualitatively based on the rate of bass nest de-watering, potential black bass habitat characteristics within the Thermalito Afterbay, review of the available literature, and best professional judgment of qualified fisheries biologists. SP-F3.1 Task 4C evaluated black bass nest de-watering in the Thermalito Afterbay. Although surveys were conducted as part of SP-F3.1 Task 4C, it should be noted that the bass nests identified during the 2003 survey efforts did not constitute a comprehensive representative sample of the Thermalito Afterbay. The bass nest snorkel and boat survey results simply represent the conditions within the coves surveyed within the northern one-third of the afterbay. Because the locations of the data collection sites are limited, data should not be interpreted as representing all available bass nesting habitat throughout the entire Thermalito Afterbay. According to habitat maps produced for SP-T4, a large portion of the fluctuating littoral zone potentially available for black bass nesting habitat exists in the southeast portion of the Thermalito Afterbay. Nest surveys in this area were unsuccessful die to the high turbidity levels with visibilities to less than a meter during the 2003 spawning period.

Analysis performed during the bass nest de-watering study included characterization of potential nesting habitat in the Thermalito Afterbay. Characterization of potential habitat included combining daily stage elevation data with data on vegetation found in and around the Thermalito Afterbay to categorize the littoral habitat. DWR staff mapped vegetation in and around the Thermalito Afterbay according to methods described in SP-T4, *Biodiversity, Vegetation Communities, and Wildlife Habitat Mapping*. Vegetation classes and distribution were digitized from 1999 georeferenced aerial photographs (1:12,000) using Arcview software (pers. comm., Kuenster 2004). Figure 4.1-1 shows the location of each vegetation type associated with the Thermalito Afterbay. A complete description of the methodology utilized in the analysis of black bass nest de-watering and characterization of potential nesting habitat in the Thermalito Afterbay are presented in the SP-F3.1 Task 4C (DWR 2004) report.

5.0 STUDY RESULTS

5.1 FISH SPECIES COMPOSITION

Fish species known to be present in the Thermalito Afterbay are listed in Table 5.1-1. This compilation of fish species is based on data collected during electrofishing efforts conducted during 2002 and snorkel surveys conducted during 2003.

Table 5.1-1 Fish Species Present in Thermalito Afterbay

Species	Native/Introduced
Rainbow trout[a]	Native[b]
Brook trout[c]	Introduced
Brown trout[e]	Introduced
Largemouth bass	Introduced
Smallmouth bass	Introduced
Spotted bass	Introduced
Redear sunfish	Introduced
Black crappie	Introduced
Bluegill	Introduced
Wakasagi[d]	Introduced
Golden shiner	Introduced
Channel catfish	Introduced
Common Carp	Introduced
Hitch	Native
Sacramento sucker	Native
Sacramento pikeminnow	Native
Sculpin sp.	Native
Tule perch	Native

a. Rainbow trout are assumed to have migrated into the Thermalito Afterbay from the Thermalito Forebay.
b. Although rainbow trout are considered native to the Feather River drainage, strains of rainbow trout stocked in the Thermalito Forebay were not endemic to the Feather River watershed
c. Brook trout are assumed to have migrated from the Thermalito Forebay to the Thermalito Afterbay.
d. Wakasagi likely migrated downstream from Lake Almanor.
e. Brown trout likely migrated downstream from Lake Oroville

In addition to those fish confirmed to be present in the Thermalito Afterbay, there is a strong likelihood that most sportfish within the Oroville area probably occur in the Thermalito Afterbay to some degree (pers. comm., See 2003a).

5.2 FISHERIES MANAGEMENT AND HATCHERY OPERATIONS

No stocking of sportfish in the Thermalito Afterbay has occurred since the 1980s when an attempt was made to stock striped bass. Catchable-sized brook trout and rainbow trout are stocked in the Thermalito Forebay and some of these fish likely migrate through the Thermalito Pumping-Generating Plant into the Thermalito Afterbay.

5.3 JUVENILE BASS RECRUITMENT

The Thermalito Afterbay is a popular largemouth bass fishery (DWR 2001). No stocking of any sportfish has occurred in the Thermalito Afterbay since the 1980s indicating that a self-sustaining bass fishery exists in the afterbay.

Water surface elevations can fluctuate rapidly and frequently in the Thermalito Afterbay resulting in a high degree of variability in water levels from day-to-day and from week-to-week, depending on project operations. Figure 5.3-1 shows surface water stage elevation from February through July of 2000, 2001, 2002, and 2003. It should be noted that 2003 was not typical of project operations as it does not include pump-back operations that results in fewer and lower magnitude water surface level fluctuations compared to normal operating years.

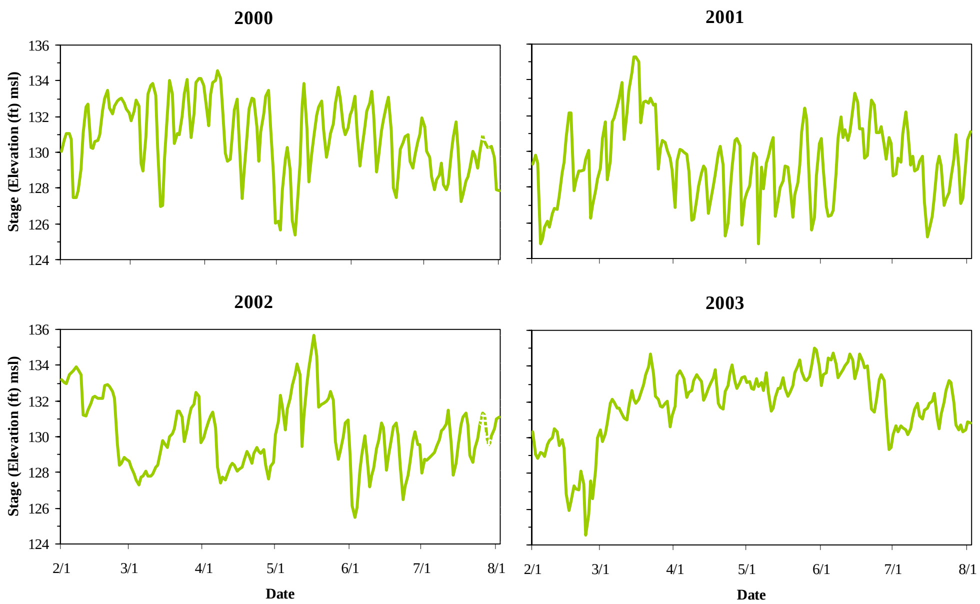

Figure 5.3-1. Thermalito Afterbay mean daily stages (ft) from February 1 through August 1 2000, 2001, 2002, and 2003.

Because the Thermalito Afterbay has a large surface area-to-volume ratio, small changes in stage elevation result in relatively large changes in water storage, and relatively large increases in inundated littoral area.

Typically the Thermalito Afterbay fluctuates from 124 ft to 136 ft above mean sea level (msl). Little or no vegetation occurs below the 127 ft msl elevation. A mostly continuous band of emergent vegetation (approximately 852 acres) occupies the lower margins from about 128 ft to 130 ft msl. Approximately 380 acres of this lower margin are occupied by mostly pure stands of rushes (*Juncas effuses*) and 234 acres are occupied by mixed emergent vegetation, with a few pockets (less than one acre) of cattail (*Typha sp*) and bulrush (*Scirpus acutus*). Above this wetland vegetation band, a ring of rush/verbena occurs (pers. comm., Kuenster 2004).

In SP-F3.1 Task 4C, *Characterization of Inundated Littoral Habitat and Evaluation of Effects of Surface Water Fluctuations on Bass Nest Dewatering in the Thermalito Afterbay*, a model was developed to estimate the occurrence of bass nest dewatering. Parameters to the model included habitat characterization as described above, snorkel survey data of bass nests in the Thermalito Afterbay, historical stage data, and available literature review of black bass spawning. Results of the model output indicated that the current operationally induced surface level fluctuations in the Thermalito Afterbay appear to favor spotted bass production, have an intermediate negative effect on smallmouth bass, and would result in the least favorable conditions for largemouth bass (DWR 2004). Complete description of the results of the black bass nest de-watering study conducted for the Thermalito Afterbay are presented in the SP-F3.1 Task 4C (DWR 2004) report.

Positive effects also may be associated with reservoir fluctuations. For example, low reservoir levels cause concentration of adult fish and the forage base in a relatively small area due to the decrease in the total volume of water, resulting in adult fish with better condition factors. Additionally, aquatic weed growth is controlled with water surface fluctuations, without which excessive aquatic plant growth may limit the amount of available fish habitat. A certain amount of aquatic vegetation is beneficial to Thermalito Afterbay fisheries because it provides escape cover for juvenile fish and increases food supply, but too much aquatic vegetation (greater than approximately 30 percent) could lead to negative impacts to planktonic communities, repressed feeding efficiency of adult fish, and seasonal decomposition-related oxygen depletion (DWR 2002). Water surface elevation fluctuations in the Thermalito Afterbay currently are frequent and sufficient to prevent excessive aquatic vegetation growth.

According to Lee (1999), juvenile black bass habitat is optimum at reservoir levels that inundate the most and best microhabitat. Usually this elevation occurs at or near maximum pool elevations in fluctuating reservoirs in California. Receding water levels that subsequently expose shoreline areas with little cover for juvenile fish can affect survival. The degree of the impact will depend upon magnitude and timing of the drawdown, shoreline gradient, and the amount and quality of habitat remaining inundated (Lee 1999). In an abundance and distribution study on juvenile largemouth bass in Lake Nacimiento, California, Von Geldern (1971) reported that excessive reservoir drawdown during the spawning season can result in year class failures.

Other than frequent water surface elevation fluctuations, which may be particularly detrimental to bass nest survival, the Thermalito Afterbay provides good habitat for black bass. The presence of large schools of wakasagi also provides an excellent forage base for adult black bass. The availability of good habitat plus a good forage base may partially offset the negative impact of bass nest de-watering associated with water surface level fluctuations. Fisk and Von Geldern (1983) *in* Dill and Cordone (1997) however, have hypothesized that young wakasagi and young black bass might be competitors and discourage wakasagi introductions into waters supporting black bass fisheries.

If nest building species, such as black bass in the Thermalito Afterbay, have some ability to adjust their spawning depths in response to continually and rapidly fluctuating water levels, recruitment could potentially be increased (Bratovich 1985). Centrarchid fishes have been known to adjust spawning depths in response to water level fluctuations in other water bodies. Kramer and Smith (1962) reported a direct relationship between water level fluctuations and median depth of largemouth bass spawning in West Slough, Lake George, Minnesota. Additionally, Bennet and Gibbons (1972) observed an adjustment in the spawning depth of largemouth bass and bluegill of up to 11.5 ft in response to daily water level fluctuations in Leesville Lake, Virginia.

Oroville Facilities operations also affect water temperatures and their distribution in the Thermalito Afterbay, which affects coldwater and warmwater fish habitat quantity, quality, and distribution. Project operations that affect Thermalito Afterbay water temperatures include Oroville Dam release water temperatures and those operational variables that determine the effective residence time of water in the Afterbay. Oroville Facilities operations that determine the effective residence time of water in the Afterbay include the volume of inflows compared to total releases (at both the Thermalito Afterbay Outlet and the agricultural diversions), afterbay stage elevations, and the magnitude and frequency of peaking and pump-back operations.

Cooler water temperatures prolong the period of nest development and expose eggs or sac-fry to extended predation (Allan and Romero 1975). Lee (1999) reported that black bass spawning duration also is influenced by water temperature. Higher water temperatures shorten the hatching and fry development period, resulting in increased nesting success, while cooler water temperatures would prolong the period and increase the chance of nest desiccation (Lee 1999). Eipper (1975) found a relationship pattern of survival and mortality based on seasonal water temperature. The pattern is one of lower-than-average brood survival in years having below-normal water temperatures during the first few weeks or months following spawning, and generally higher-than-average survival in years of above normal water temperatures for smallmouth bass and largemouth bass (Eipper 1975).

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Task 4A is a subtask of SP-F3.1, *Evaluation of Project Effects on Fish and their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.* Task 4A fulfills a portion of the FERC application requirements by detailing the effects of project operations on both fish species composition and juvenile bass recruitment in the Thermalito Afterbay. In addition to fulfilling these requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

Coldwater fish species found in the Thermalito Afterbay include rainbow trout, brown trout, and brook trout. It is not likely that these fish form self-sustaining populations in the Thermalito Afterbay and are likely immigrants from the upstream stocked coldwater fisheries in the Thermalito Forebay and Lake Oroville.

Warmwater fish species known to be present in the Thermalito Afterbay include wakasagi, golden shiner, bluegill, largemouth bass, smallmouth bass, spotted bass, hitch, Sacramento pikeminnow, Sacramento sucker, sculpin, redear sunfish, channel catfish, carp, black crappie, and tule perch. Although not verified in survey data, it is assumed that most sportfish observed in the Oroville area are also present in the Thermalito Afterbay (DWR 2001), which would include spotted bass and white crappie. The presence of large schools of wakasagi indicate a good forage base for the resident black bass population.

6.2 PROJECT RELATED EFFECTS

Water surface elevations in the Thermalito Afterbay can change on a weekly and daily basis, depending on power generation and pump-back operations. The shallow nature of the Thermalito Afterbay results in significant water surface fluctuation effects with only a few feet of water surface elevation change (DWR 2001). Mudflats can be exposed and a significant amount of the littoral zone can be dewatered, which affects the quantity of habitat available to fish species. Additionally, project operations affect water temperatures in the Thermalito Afterbay, which, in turn, affect black bass spawning and embryo incubation success (Lee 1999). Because the thermal regime of the Thermalito Afterbay is complex and the thermal environment to which black bass and black bass nests are exposed could change rapidly, the affect of changing water temperatures on juvenile black bass recruitment is unclear.

Because this analysis of juvenile bass recruitment primarily is based on bass nesting success rather than juvenile-to-adult ratios, the conclusions on black bass recruitment in the Thermalito Afterbay are similar to the conclusions drawn from the SP-F 3.1 4C study on bass nest dewatering. Specifically, continued operation of the Oroville Facilities in a manner consistent with current operations would be expected to result in favorable nesting and spawning conditions for spotted bass, an intermediate negative effect on smallmouth bass, and the least favorable conditions for largemouth bass nesting and spawning when compared with these other species. However, the species composition data compiled for this report indicates that largemouth bass is the primary bass species occurring in the Thermalito Afterbay, so consideration of project impacts should be directed to this species.

The persistence of a self-reproducing largemouth bass population indicates that the nesting and spawning conditions under the current operations are sufficient to sustain this fishery, though relatively low angler and electrofishing catch rates, as well as a low number of juvenile bass and nest observations seems to indicate a relatively low number of largemouth bass. This may be a result of the habitat conditions at the Thermalito Afterbay that may be less than ideal for largemouth bass, but still allow the fishery to persist. However the complex hydrology and morphology of the Afterbay may also influence these results. Because the Afterbay is comprised of open water, as well as large areas of shallow water with dense emergent marsh vegetation, fish sampling was difficult and inconsistent. Boat electrofishing is a common warm water fish sampling technique in California reservoirs, and this was used on numerous occasions at the Afterbay. However, the electrofishing boats had difficulty accessing many of the shallow, vegetated bays of the Afterbay, so only the deeper portions of these areas were sampled on a regular basis, typically around large stands of bulrush (*Scirpus spp*.). The open water immediately adjacent to these heavily vegetated area is not sampled very effectively with electrofishing because fish are dispersed and can easily avoid the boat, and these areas are not the primary habitat for warm water fish. Other techniques such as snorkel surveys and seining were also difficult to employ for the same reasons, as well as periodic high turbidity levels, and it is likely that these conditions also reduce angler success.

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